SECRET

c.1

097.3
Z1092
No. 693

OFFICE OF STRATEGIC SERVICES

Research and Analysis Branch

DEPARTMENT OF STATE
REFERENCE DIVISION
FILE COPY
PLEASE RETURN
REF

GERMAN AIRCRAFT PRODUCTION, LOSSES, AND STRENGTH

~~Report No. 105~~

R & A 693

December 24, 1942

Copy No. 44

(8800)

TABLE OF CONTENTS

		Page
INTRODUCTION		i
I.	GERMAN AIR FORCE OPERATIONS	1
II.	WASTAGE AND OTHER REQUIREMENTS	5
	A. Combat Losses	5
	B. Operational Losses	7
	C. Factory Repair Pool	9
	D. Allocations to Training	11
III.	GERMAN AIRCRAFT PRODUCTION	15
	A. Ministry of Economic Warfare Estimate	15
	B. Air Ministry Estimate	15
	C. Other Estimates	17
	D. Production and Wastage	19
IV.	STRENGTH	20
	A. Strength Estimates	20
	B. Strength in Relation to Production and Wastage	21
V.	AN OSS PATTERN OF PRODUCTION, LOSSES, AND STRENGTH	30
	A. Production	30
	B. Wastage and Strength	33
	C. Distribution of Strength	33
APPENDIX I.	GERMAN AIRCRAFT PRODUCTION BY TYPES AND MODELS	36
APPENDIX II.	GERMAN PRODUCTION OF AIRPLANE ENGINES AND THE PROBLEM OF OBSOLESCENCE	49
	A. Increase in Horsepower	49
	B. The Timing of Model Changes	50
	C. Summary	53

INTRODUCTION

This study represents an attempt to analyze a mass of data and estimates relating to German aircraft production, requirements, and strength. It also offers, after measuring and resolving the varying figures, a whole consistent set of estimates in which emphasis has been placed upon the overall schematic pattern of a monthly time-series form rather than upon disparate, if well-supported, estimates for isolated dates or periods of time.

The strength of the German Air Force will be seen to have been determined by means of a simple equation: production over time less wastage (and other deductible factors) over time equals strength at a terminal period of time. In keeping with this formula and, perhaps in logic, too, production, wastage, and strength should have been discussed in that order. But inasmuch as available German production estimates must be tested by German needs or requirements, which are based on losses of all kinds, the order of discussion in the following pages has been losses (including all sources of depletion from strength) production, and strength.

It will be observed that wastage and other requirement estimates have been constructed on the basis of pilots' claims, analogies with other air forces, and certain subjective considerations. These estimates, in turn, have been applied against various production figures from which, as in the equation cited above, GAF strength for any specific period of time has been derived. Operational intelligence regarding GAF strength and disposition has also been absorbed and related to the formulated strength estimates. The result consists of a coherent estimate pattern which is designed to satisfy the logic of the functional relationships among the several estimates while doing least violence to available intelligence material.

Estimates of initial equipment in first-line squadrons are given by types of tactical planes and by theatres of operations. Supporting appendices are devoted to the implications of overall production estimates for the output of various aircraft models and airplane engines.

Since trainer planes and transports have been excluded from the calculations of this study, all estimates relate only to such tactical types of planes as bombers, fighters, army cooperation, and coastal operations.

Much of the material of this study has been furnished by the Air Ministry, the Ministry of Economic Warfare, the Air Group of MIS, and the Intelligence Service of the Army Air Forces.

SECRET

GERMAN AIRCRAFT PRODUCTION, LOSSES, AND STRENGTH

I. GERMAN AIR FORCE OPERATIONS

The following brief chronicle of GAF operations is designed to provide an operational background for certain changes in the statistical summary and discussions which follow.

September 1939:

The assault upon Poland, the opening chapter in World War II, was characterized by the rapid destruction of the Polish Air Force, largely on the ground, by the GAF. Eighteen hundred German planes were used in close cooperation with the ground forces, in shattering communications, and in dive and low-level attacks upon railroads, bridges, troops and civilians.

October 1939-April 1940:

Increasing its first-line strength from 4,300 to 5,600 planes, the GAF employed the six months lull following the Polish campaign for reconnaissance, fighter patrols, intermittent small-scale attacks on shipping and, above all, intensive training.

April 1940:

Suddenly emerging from the period of apparent inaction, 800 German combat planes and 250-300 troop-carrying transports heralded the Blitz against Norway. With little opposition, the GAF quickly cleared the way for the spearhead of Germany's invasion, forestalled the mobilization of Norway's army, and frustrated the British in their attempt to land on Norwegian shores.

May-June 1940:

The blow against Norway was immediately succeeded by the stunning conquest of the Low Countries and France and the enforced B.E.F. evacuation of Dunkirk. Throughout the campaign, the GAF was intensely active, transporting parachutists and airborne infantry, especially in the Netherlands, dive-bombing paths for the panzer divisions, and smashing French rail communications and ports with medium and heavy bombers.

July 1940:

Relaxing from the extraordinary activity of the "campaign of the West" the GAF employed the hot July days and the first week of August to equip itself anew and to organize Reserve training units (R.T.U.'s) to provide for pilot replacement -- a lesson learned in the Battle of Flanders.

August-October 1940:

On August 8, the GAF unleashed its historic attack upon the British Isles. Until August 18, it relentlessly pounded English shipping, ports, airdromes, and aircraft factories. But by that date 697 German planes had been lost. So great were the casualties among dive-bombers that their use was thereafter abandoned. Permitting themselves only a slight pause, German bombers, accompanied at day by fighter escorts, resumed their work of destruction, concentrating upon airdromes and factories in an attempt to eliminate the RAF fighter resistance. Between August 24, and September 5, 562 German planes were shot down in this operation. During the following month German bombing forays were leveled at industrial and residential targets, particularly in London, but the GAF sacrificed 883 aircraft, including 185 on one day, September 15. Then turning from day to night attacks, the GAF let loose its power upon the British capital on October 6.

Its mass onslaughts halted by heavy losses in flying personnel and reduced reserves, the GAF could look upon the Battle of Britain as a great failure in which it had lost 2,375 planes in combat.

November 1940-April 1941

The GAF's winter night operations over Britain opened with the concentrated raid on Coventry in November and continued on a level of 200 planes per night of activity.

Meanwhile it extended its area of attacks to include Malta; Sicilian airdromes were used as bases beginning in January 1941, and from that date through May the British island in the Mediterranean was subjected to constant bombardment.

The invasion of Yugoslavia and Greece in April betrayed the by now familiar pattern of conquest. Army cooperation and transport planes were used freely with little effective air resistance. Harbors and shipping were bombed heavily. Within a month both Balkan countries were prostrate.

May 1941:

The curtain was drawn on a new theatre of operations for the GAF when it replaced night raids on English cities with moderate scale attacks on Atlantic shipping in which long-range reconnaissance planes cooperated with submarines.

At this time, too, and after weeks of preparations and reconnaissance, Crete was stormed from the air. Bombing the island's airdromes heavily, the Germans captured Crete with 10,000-15,000 parachute and airborne troops conveyed by 600 transport planes.

June-November 1941:

Notwithstanding its broad range action in the bygone year, the GAF achieved its maximum overall strength, and its greatest depths of

reserves behind its first line squadrons, with a total holding of 10,000 airplanes. Half of its squadrons were already allocated to the planned Blitz against Russia which began on June 22. Here the Luftwaffe operated in close support of ground troops with low-flying attacks upon military objectives, bombing of airdromes and communications, and reconnaissance. German air superiority was achieved by concentrating its forces in principal battle areas against effective Russian resistance rather than over the entire Red front. This was made possible by the high mobility of the German squadrons. In August and September Leningrad was threatened, and in October Moscow seemed mortally endangered but with the extreme winter conditions which obtained by the end of that month the Northern offensive drew to a close.

December 1941:

Suffering heavy air losses in Russia, the GAF withdrew to Germany squadrons whose organizational strength totalled 800 planes. The remaining 1,600 aircraft operated defensively under the intense difficulties of extreme cold and inadequate airdrome facilities. The first-line strength of the GAF dropped from 4,550 to 4,050 planes; serviceability at the front fell to 30 percent. But the opportunity was seized to re-equip squadrons and create a reserve for the 1942 campaign.

January-April 1942:

Sustained aerial assaults upon Malta, resumed in December, resulted in severe damage inflicted upon the GAF by the Maltese defenders. While troop transports assembled on Mediterranean airdromes, other units of the GAF participated in Rommel's African campaign, dive-bombing British-held airfields, and aiding ground troops with fighter and reconnaissance operations. Supplies were carried by air from Crete to Cyrenaica because of the difficulties of sea transport.

On the Western front there was little activity. While RTU's were pressed into service as a reply to the heavy attacks of the RAF, the Germans exhibited a reluctance to engage the British in battle, and the scale of activity against British targets was far below that of October 1940-May 1941.

In Russia, too, the German Air Force operations were relatively slight, and the rates of loss remained high as Russian resistance, and operational difficulties in that area persisted.

May-August 1942:

The German eastward drive in North Africa was launched in May with intensive bombing attacks upon British-held airdromes and dive-bombing forays on troops, gun-batteries, and tank and truck concentrations. By June Tobruk had fallen and the British were about to withdraw to El Alamein.

In Russia the Germans resumed the great offensive in May, using the major portion of its first-line air strength on this front. At the

expense of reserves, initial squadron strength of the GAF was raised to 4,700 planes in August. The advance in the Caucasus was supported by 1,500 planes. Sevastopol fell to the Germans in June after planes were introduced to supplement siege artillery. But Germany's offensive power was restricted to one sector at a time, partly because of the need to conserve planes and airplane personnel. The tightness of both these elements was reflected in the GAF's conservative air operations in western Europe despite RAF raids on Germany and France. The battle in mid-August with the British air support of the Dieppe Commando raid cost the Luftwaffe one-third of its fighter strength in the West.

September 1942:

One thousand planes took part in the frontal attack on Stalingrad of September 7. During the following week the peak of the year's losses was reached. Thereafter air activity was reduced sharply owing to the decline in serviceability and the shortage of reserves.

October 1942:

Hitler's admission on October 1, that Germany was on the defensive in the West was followed by statements of Goering and Goebbels in which the implication was clear that the GAF could not cope with British air raids over Germany and Axis-Europe and operate offensively on the Russian front as well.

November 1942:

The major thrust westward of the British 8th Army in Egypt-Libya, the occupation of North Africa by U.S. and allied forces, and the Soviet counter-offensive on three sectors of the Eastern Front all combined to drain the strength of the GAF. The British thrust through to El Agheila resulted in the capture of several hundred grounded unserviceable German craft. Squadrons were withdrawn from the East, especially from the units previously engaged in attacks on the northern convoy route to Russia, to meet the weight of United Nations' attack against Bizerte and Tunis.

II. WASTAGE AND OTHER REQUIREMENTS

In the paragraphs below, "wastage" is defined to comprehend planes destroyed a) in combat; b) in operations connected with combat missions; and c) in flying accidents behind the lines, and to have been destroyed or damaged beyond the ability of the enemy to repair them. It includes planes in operating squadrons, and planes in transit between or to such squadrons from factories or stored reserves. "Other requirements" consists of badly damaged but reparable planes sent back from squadrons to factories for repairs, and combat planes which have to be allocated to the German training program of preparing pilots and other flying personnel to handle operational types of planes in squadrons.

A. Combat Losses

One source of information relating to GAF combat losses is the data assembled by the British Air Ministry for all theatres of operations except that of the Eastern Front. Published in the Air Ministry Weekly Intelligence Summary (AMWIS) pilots' claims of losses inflicted upon the enemy are tabulated and arranged according to those planes "destroyed," those "probably destroyed," and those "damaged."

In this study, one-half of the aircraft listed as "probably destroyed" have been assumed to be in the same category as "destroyed." This combined quantity is included among the planes lost in combat. The other half of the airplanes "probably destroyed" and all of those described as "damaged" are treated among "operational losses," discussed in the succeeding Section B, or in planes under repair at factories (Section E).

Table I, on page 6, sets forth in the form of monthly series and by theatres of operations, excluding Russia, estimates of battle losses. Cumulative figures from later issues of the AMWIS, and from periodic, but sometimes modified announcements of official British and other national sources, have been the basis for these estimates.

Data relating to GAF losses on the Eastern Front have been found only in Russian and German communiques, except for sporadic intelligence reports of dubious reliability. But the discrepancy between German admissions of their own losses and Russian claims of losses inflicted upon the German Air Force is so great as to make each type of information valueless. In lieu of these contradictions, another method of estimating GAF losses on the Russian front has been adopted.

It has been found that Russian admissions of their own losses, revised to adjust the original daily and weekly communique figures to occasional summaries covering several months each, fall about midway between Russian claims of German losses and German admissions of these losses. These Russian admissions of their own losses have been accepted as a measure of GAF losses in the Russian theatre of operations.

TABLE I
G.A.F. Combat Losses

Date	Total	Losses to British 3/ Total	Over United Kingdom	Over Western Europe	In Mediterranean	Losses to Others Prior to June/1941 1/	Losses to Russia 2/
1939							
Sept.	222	12	5	7	-	210	-
Oct.	24	14	6	8	-	10	-
Nov.	26	16	7	9	-	10	-
Dec.	28	18	8	10	-	10	-
1940							
Jan.	30	20	10	10	-	10	-
Feb.	30	20	10	10	-	10	-
Mar.	30	20	10	10	-	10	-
Apr.	110	75	19	56	-	35	-
May	1,400	700	50	650	-	700	-
June	1,000	500	50	450	-	500	-
July	100	100	50	50	-	-	-
Aug.	1,101	1,101	1,091	10	-	-	-
Sept.	1,259	1,259	1,249	10	-	-	-
Oct.	450	450	440	10	-	-	-
Nov.	325	325	315	10	-	-	-
Dec.	325	325	315	10	-	-	-
1941							
Jan.	170	170	50	10	110	-	-
Feb.	125	125	50	10	65	-	-
Mar.	125	125	50	10	65	-	-
Apr.	630	530	135	60	335	100	-
May	510	510	145	85	280	-	-
June	855	355	135	165	55	-	500
July	1,250	375	50	270	55	-	875
Aug.	1,230	230	--	190 --	40	-	1,000
Sept.	1,595	195	--	175 --	20	-	1,400
Oct.	1,045	70	--	50 --	20	-	975
Nov.	545	170	--	40 --	130	-	375
Dec.	560	410	--	85 --	325	-	150
1942							
Jan.	340	115	--	15 --	100	-	225
Feb.	375	100	--	35 --	65	-	275
Mar.	540	190	--	75 --	115	-	350
Apr.	630	330	--	105 --	225	-	300
May	1,085	385	--	150 --	235	-	700
June	1,030	255	--	140 --	115	-	775
July	1,170	370	--	75 --	295	-	800
Aug.	1,335	385 3/	--	195 --	190	-	950
Sept.	1,169	244 3/	--	113 --	131	-	925
Oct.	889	514	--	158 --	356	-	375
Nov. (Prel.)	540	265	--	102 --	163	-	275

Includes losses to Poland, Norway, the Netherlands, Belgium, France Yugoslavia, and Greece.

2/ Based on Russian admissions of Russian losses.

3/ Includes losses to U.S.A.A.F.

(8800)

This has been done because 1) it may be assumed with reason that Russian admission of their own losses serve, at the very least, as an index to the intensity of air activity on the Eastern Front (except, perhaps, for the days of June 1941, when large numbers of Russian planes were destroyed on the ground). 2) Russian admissions of their own losses would not be greater than those actually suffered by the Soviets, nor is it likely that Russian losses would be greater than German losses since Russian aerial activity has not been as intense as the Germans and since Russian planes are not seriously inferior to German planes. Moreover, 3) it may be believed that the Russians would be unwilling to admit losses higher than those known to have been suffered by the Germans.

For the period June 22-June 30, 1941, German losses have been arbitrarily taken to be 500 planes, on the grounds that air activity must have been of the greatest intensity for the GAF to have succeeded in destroying 1,800 Russian planes, even though the greater part of these aircraft were on the ground at the time of their destruction.

Table II, on page 8, presents the loss figures as shown in the original communiques, the Russian admissions of their own losses as revised to accord with the summaries, and the German losses as inferred from Russian admissions. It will be noted that this last category of GAF losses is also shown in the last column of Table 1.

B. Operational Losses

Numbers of planes are destroyed in connection with combat missions in addition to those quantities of aircraft claimed by pilots to have been shot down or "probably destroyed." Of the former type of destroyed planes there are those which have been destroyed or damaged beyond repair while on take-offs or landings, or on forced landings at inaccessible points. Since these losses, while not directly of a combat character, result from operations directed against the enemy, they are a function of the intensity of air warfare, and have been estimated as a proportion of actual combat losses.

The experience of the RAF in the metropolitan area over a number of recent months, leads to the assumption that the quantity of planes destroyed incidental to enemy action amounts to 30 percent of combat losses, while planes badly damaged in action or incidental to action with the enemy amount to an additional 27 percent of battle losses.

RAF experience also is the basis for the belief that 30 percent of the planes returned by forward echelons for repairs at the factory are not, in fact, repaired at all because of shortages of parts, labor, etc. If these unrepaired planes are added to those destroyed incidental to enemy action, then operational losses are equivalent to 38 percent of combat losses.

Operational losses vary according to the two principal flying seasons, winter and summer. Again resorting to RAF experiences, the GAF is estimated to have suffered operational losses as high as 60 percent in winter and as low as 30 percent in summer. These operational losses (expressed

TABLE II

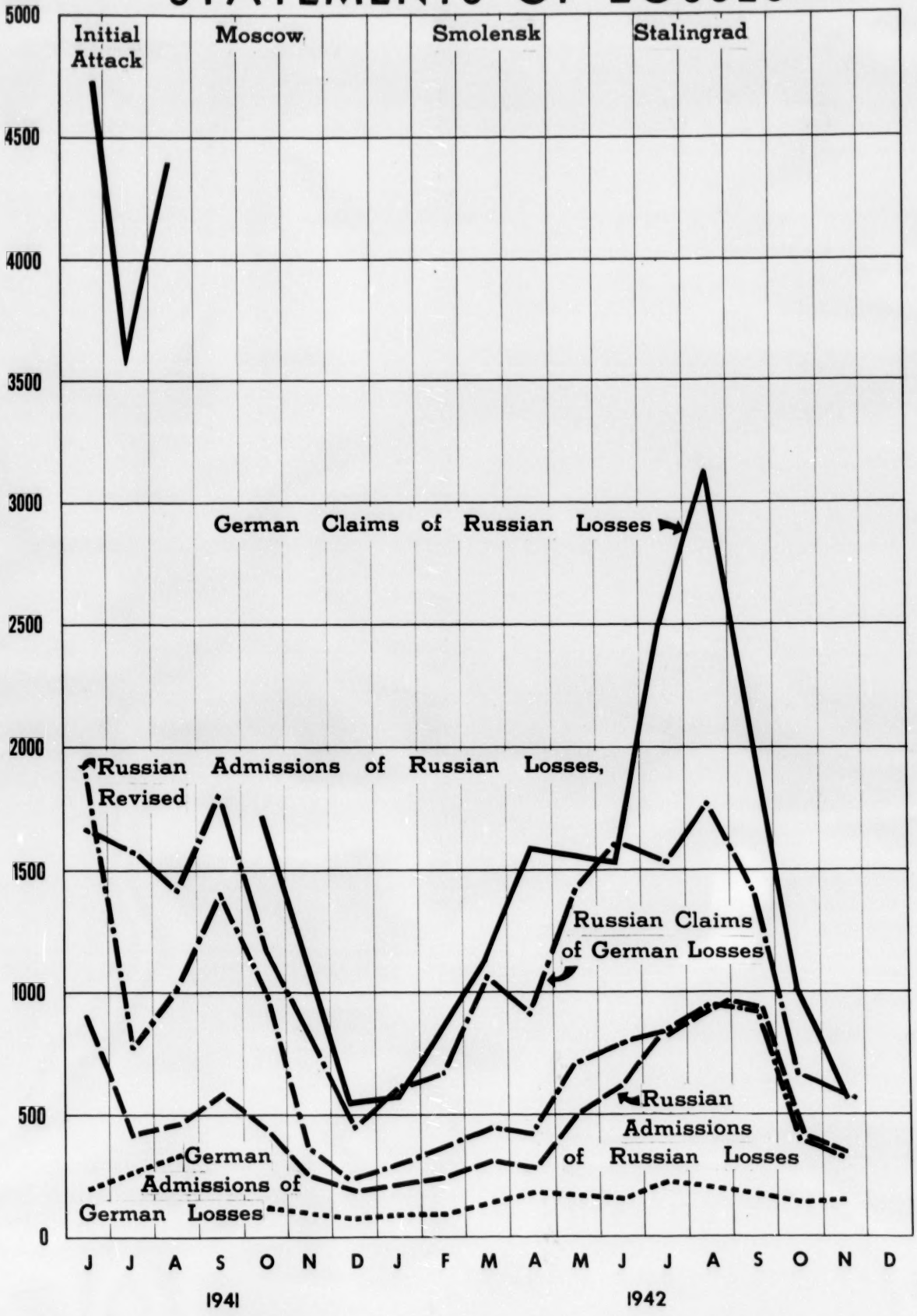
Official Statements of German and Russian Losses On the Eastern Front

Date	As Reported in German Communiques		As Reported in Russian Communiques			
	Claims of Russian Losses	Admission of German	Claims of German Losses	Admission of Russian Losses	Russian Admissions Revised 1/	German Losses Inferred from Russian Admissions
1941						
June						
(22-30)	4,725	172	1,655	872	1,880	500
July	3,540	250	1,575	402	865	875
Aug.	4,402	330	1,409	466	1,005	1,000
Sept.	-	-	1,773	645	1,389	1,400
Oct.	1,728	145	1,174	453	978	975
Nov.	1,111	96	821	192	366	375
Dec.	529	64	445	110	151	150
1942						
Jan.	553	85	571	154	213	225
Feb.	849	78	627	191	263	275
Mar.	1,141	93	1,040	257	354	350
Apr.	1,576	162	881	224	309	300
May	1,551	152	1,419	500	689	700
June	1,535	145	1,640	618	765	775
July	2,506	211	1,548	803	803	800
Aug.	3,213	172	1,783	947	947	950
Sept.	2,134	141	1,435	915	915	925
Oct.	991	85	679	365	365	375
Nov.	591	101	604	278	278	275

1/ Summations of daily and weekly figures revised to accord to occasional summary communiques.

CHART I

GERMAN and RUSSIAN OFFICIAL STATEMENTS OF LOSSES



in terms of percentage of combat losses) of the GAF apply to Poland, Western Europe, and the Balkans.

In Russia, the more remotely located factory repair shops doubtlessly reduce the numbers of badly damaged planes which can be repaired. Therefore a proportion of 50 percent, rather than 38 percent of combat losses is taken to apply generally on the Eastern Front, with 33 percent for summer, and 65 percent for winter.

(It has been assumed that "winter" operational-loss ratios cover the months from November through March in Western Europe and the British Isles, while it carries on through April on the Eastern Front where no separate allowance has been made for the southern sector. In the Mediterranean area it has been assumed that the "summer" ratio prevails throughout the year).

RAF Metropolitan history cannot, of course, be applied with too great a degree of precision to the GAF. Weather over the British Isles is more erratic than over the continent, and to that extent operational losses of the RAF are necessarily higher. Furthermore, RAF Metropolitan experiences are not comparable to the Luftwaffe's problems in the Mediterranean where such difficulties as sand, etc., may bring GAF operational loss to the level of 50 percent of combat losses. In its sorties against Yugoslavia, Greece, and particularly Russia, the GAF operates under far more disadvantageous conditions than the RAF Metropolitan force in the matter of landing fields, navigational aids, etc.

Flying accidents disassociated from enemy action, perforce take a certain toll of planes as they are moved behind the lines, from base to base, or from factory to front, and as pilots are sent aloft on training flights. This type of loss must be calculated in light of the intensity of such movement behind the lines. In lieu of any specific data, it has been assumed that flying accidents consume 2 percent of first-line strength including reserves, each month. (Figures for first-line strength are shown and discussed in Chapter IV)

Table III, on page 10, indicates operational losses, flying accidents, and total wastage.

C. Factory Repair Pool

It is clear that planes damaged in combat or operations to such an extent that they cannot be repaired in forward echelons, but which are nonetheless repaired in the rear, are not available for service in combat units for a lengthy period. Not only must they be transported, often over long distances to repair factories, but they are repaired in a necessarily slow manner, and then subjected to time-consuming tests before being returned to service.

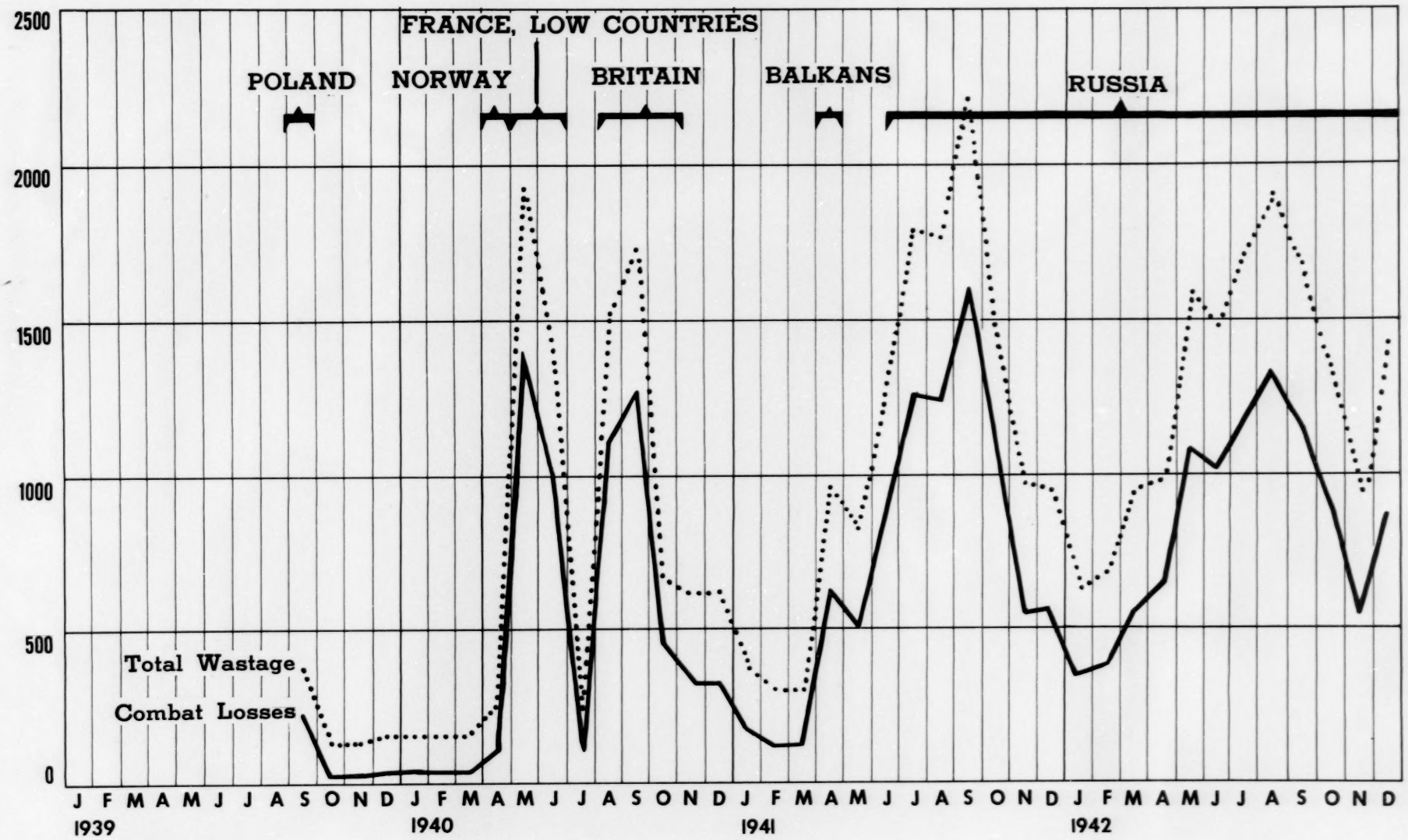
TABLE III

G.A.F. Aircraft Wastage

Date	Combat Losses	Operational Losses-Western Front (& Poland)	Operational Losses-Mediterranean	Operational Losses-Eastern Front	Flying Accidents	Total Wastage	Rounded
1939							
Sept.	222	67	-		88	377	375
Oct.	24	7	-		90	121	125
Nov.	26	16	-		91	133	125
Dec.	28	17	-		93	138	150
1940							
Jan.	30	18	-		94	142	150
Feb.	30	18	-		96	144	150
Mar.	30	18	-		98	146	150
Apr.	110	33	-		108	251	250
May	1,400	420	-		112	1,932	1,925
June	1,000	300	-		112	1,412	1,400
July	100	30	-		116	246	250
Aug.	1,101	330	-		104	1,535	1,525
Sept.	1,259	378	-		92	1,729	1,725
Oct.	450	135	-		92	677	675
Nov.	325	195	-		96	616	625
Dec.	325	195	-		100	620	625
1941							
Jan.	170	36	55		105	366	375
Feb.	125	36	32		109	302	300
Mar.	125	36	32		115	308	300
Apr.	630	58	167		115	970	975
May	510	69	140		116	835	825
June	855	90	27	165	118	1,255	1,250
July	1,250	96	27	290	116	1,779	1,775
Aug.	1,230	57	20	330	107	1,744	1,750
Sept.	1,595	52	10	460	91	2,208	2,200
Oct.	1,045	15	10	320	88	1,478	1,475
Nov.	545	24	65	245	85	964	975
Dec.	560	51	162	100	81	954	950
1942							
Jan.	340	9	50	145	82	626	625
Feb.	375	21	32	180	84	692	675
Mar.	540	45	57	225	86	953	950
Apr.	630	32	112	100	89	963	975
May	1,085	45	117	230	96	1,573	1,575
June	1,030	42	57	255	96	1,480	1,475
July	1,170	23	147	265	96	1,701	1,700
Aug.	1,335	59	95	315	94	1,898	1,900
Sep.	1,169	34	65	305	88	1,661	1,675
Oct.	889	47	178	125	84	1,323	1,325
Nov. (prel.)	540	61	81	180	89	951	950

CHART 2

GERMAN AIRFORCE WASTAGE



The number of such planes in transit to, or from, or awaiting, or undergoing repair in factories -- as distinct from forward repair stations -- has been estimated so as to permit that quantity to be deducted from strength at any given point in time. Here again recourse has been had to the RAF. Badly damaged planes which will be repaired successfully have been appraised to be 30 percent of the total wastage of each month in theatres other than Russia or the Mediterranean; in the latter areas the proportion declines to 20 percent since it has already been assumed that only 50 percent of badly damaged planes will be repaired as against 70 percent in Western Europe.

The numbers of planes under repair may be calculated from repair input and repair output. Two months has been taken as the amount of time consumed by planes damaged in Western Europe, the Balkans, Poland, etc., to be sent to repair factories, to be repaired, and to be returned to the front; three months has been estimated for the same process to be applied to planes damaged on the Eastern and Mediterranean fronts. Since it is doubtful that the GAF has had available repair facilities to care for all damaged planes after operations of the highest intensity, an arbitrary capacity of repair factories has been assumed. When the repair output, based upon the above estimates of two months and three months repair time, respectively, exceeds this capacity, the return of damaged planes to active service is obviously delayed. Repair service is assumed to have increased in October 1940, after it was found that plane damage suffered in May and June exceeded the available capacity. It is also believed to have increased in January 1941, when the GAF began operations in the Mediterranean theatre, and in November 1941, and January and March 1942, when facilities in the forward area were established behind the Russian front.

Table IV, on page 12, sets forth of repair input and output, and the number of planes under, awaiting, or in transit to or from repair.

D. Allocations to Training

The necessity to use tactical planes in training represents the final drain on the supply of planes available for tactical formations. Although replacement pilots are instructed by means of basic, primary, and advanced training aircraft, they require a certain period in which they may become familiar with the planes they will fly in first-line squadrons. Such tactical planes used in training must be replaced when destroyed, damaged, or worn out. Additional quantities must be furnished whenever the size of the training group is enlarged. Conversely, however, tactical planes may be withdrawn from training if the size of the group is reduced.

Scarcely any data is available as to the numbers of planes engaged in operational training at the outbreak of the war. However, the opinion has been expressed that the GAF had allocated relatively few planes to this purpose, although it is not clear whether it was due to miscalculations of the war's duration or to an excessive optimism which

TABLE IV

Factory Repair Pool

Date	Input: West and Central Europe	Input: Medit. and Russia	Input: Total Input	Monthly Repair Capacity	Estimated Output	Net Change	Planes under, Awaiting, or in Transit to or From Repair	Rounded
1939								
Sept.	112	-	112	200	-	+112	112	100
Oct.	38	-	38	200	-	+ 38	150	150
Nov.	37	-	37	200	112	- 75	75	75
Dec.	45	-	45	200	38	+ 7	82	75
1940								
Jan.	45	-	45	200	37	+ 8	90	100
Feb.	45	-	45	200	45	0	90	100
Mar.	45	-	45	200	45	0	90	100
Apr.	75	-	75	200	45	+30	120	125
May	578	-	578	200	45	+533	653	650
June	420	-	420	200	75	+345	998	1,000
July	75	-	75	200	200	-125	873	875
Aug.	457	-	457	200	200	+257	1,130	1,125
Sept.	518	-	518	200	200	+318	1,448	1,450
Oct.	203	-	203	250	250	- 47	1,401	1,400
Nov.	187	-	187	250	250	- 63	1,338	1,350
Dec.	188	-	188	250	250	- 62	1,276	1,275
1941								
Jan.	60	33	93	275	275	-182	1,094	1,100
Feb.	62	19	81	275	275	-194	900	900
Mar.	63	19	82	275	275	-193	707	700
Apr.	110	100	210	275	275	- 65	642	650
May	124	84	208	275	275	- 67	575	575
June	152	149	301	275	267	+ 34	609	600
July	160	249	409	275	224	+185	794	800
Aug.	106	278	384	275	236	+148	942	950
Sept.	95	378	473	275	275	+198	1,140	1,150
Oct.	46	265	311	275	275	+ 36	1,176	1,175
Nov.	45	163	208	300	300	- 92	1,084	1,075
Dec.	65	147	212	300	300	- 88	996	1,000
1942								
Jan.	32	104	136	325	325	-189	807	800
Feb.	42	110	152	325	325	-173	634	625
Mar.	62	149	211	350	350	-139	495	500
Apr.	68	147	215	350	174	+ 41	536	525
May	87	256	343	350	172	+171	707	700
June	83	240	323	350	217	+106	813	825
July	58	301	359	350	234	+125	938	950
Aug.	104	310	414	350	339	+ 75	1,013	1,025
Sept.	70	285	355	350	298	+ 57	1,070	1,075
Oct.	87	207	294	350	350	- 56	1,014	1,025
Nov.	76	140	216	350	350	-134	880	875

possesses airforces before their engagement in warfare.1/ Nonetheless, it has been assumed that Operational Training Units (OTU's) began the war with 1,000 planes, reached a peak of 1,600 in May 1941, and declined thereafter to 1,500. OTU's are engaged in training with tactical planes at flying schools and bases within Germany.

Newly formed combat squadrons are held in reserve in Reserve Training Units (RTU's) and operate from advance airfields along with combat squadrons. Frequently, RTU's are formed into the fourth squadron of an operational group, or the fourth group in an operational wing. On occasion, they may be used operationally; this is particularly true of their instructor crews. RTU's were first formed in July 1940, when the rate of pilot wastage incurred in the Battle of Flanders indicated to the GAF that they needed a link between the OTU's and the operating squadrons. It has been assumed that they were first formed by diverting 300 planes from OTU's and that they were subsequently increased to 600 in May 1941.

Table V, page 14, presents a schematic pattern for the growth of OTU's. The wastages have been estimated broadly on the basis of 6 percent of strength per month for the RTU's and 8 percent per month for the OTU's. It has been assumed that after the initial transfer of planes from OTU's to RTU's growth in the latter force was provided by planes available for operating squadrons or stored reserves, although wastage is included under "allocations to training." It is known, of course, that repaired planes from repair factories and obsolescent planes from stored reserves, constitute a substantial portion of the aircraft allocated to the OTU's; this factor, however, does not alter the calculations of OTU requirements as set forth in Table V.

1/ Interview with an RAF Intelligence officer, April 1942.

TABLE V

Planes Allocated to Training

Date	Strength of Operational Training Units (1)	Wastage at 8% (2)	Growth (3)	Strength of Reserve Training Units (4)	Wastage at 6% (5)	Total Allocation to Training (2)+(3)+(5)	Rounded
1939							
Sept.	1,000	80	-	-	-	80	80
Oct.	1,040	83	40	-	-	123	125
Nov.	1,080	86	40	-	-	126	125
Dec.	1,120	90	40	-	-	130	130
1940							
Jan.	1,160	93	40	-	-	133	135
Feb.	1,200	96	40	-	-	136	135
Mar.	1,240	99	40	-	-	139	140
Apr.	1,280	102	40	-	-	142	140
May	1,320	106	40	-	-	146	145
June	1,360	109	40	-	-	149	150
July	1,100	88	40	300	18	146	145
Aug.	1,150	92	50	330	20	162	160
Sept.	1,200	96	50	360	22	168	170
Oct.	1,250	100	50	390	23	173	175
Nov.	1,300	104	50	420	25	179	180
Dec.	1,350	108	50	450	27	185	185
1941							
Jan.	1,400	112	50	480	29	191	190
Feb.	1,450	116	50	510	31	197	195
Mar.	1,500	120	50	540	32	202	200
Apr.	1,550	124	50	570	34	208	210
May	1,600	128	50	600	36	214	215
June	1,600	128	-	600	36	164	165
July	1,600	128	-	600	36	164	165
Aug.	1,600	128	-	600	36	164	165
Sept.	1,600	128	-	600	36	164	165
Oct.	1,600	128	-	600	36	164	165
Nov.	1,600	128	-	600	36	164	165
Dec.	1,600	128	-	600	36	164	165
1942							
Jan.	1,600	128	-	600	36	164	165
Feb.	1,600	128	-	600	36	164	165
Mar.	1,600	128	-	600	36	164	165
Apr.	1,600	128	-	600	36	164	165
May	1,600	128	-	600	36	164	165
June	1,600	128	-	600	36	164	165
July	1,550	124	-50	600	36	110	110
Aug.	1,500	120	-50	550	33	103	105
Sept.	1,500	120	-	550	33	153	150
Oct.	1,500	120	-	550	33	153	155
Nov.	1,500	120	-	650	33	153	155

III. GERMAN AIRCRAFT PRODUCTION

A. Ministry of Economic Warfare MEW Estimate

Until recently, the most widely accepted estimate of the output of German aircraft was that originally proposed by the MEW, and later published by the MEW and the Air Ministry in combination.1/ It rested primarily on a factory by factory capacity potential which, in turn, was deduced from facts and views of British engineers, refugees, and other informed persons, as well as from photographic indices of the floor space of airplane factories built or enlarged since the outbreak of the war. In addition, assumptions and appraisals were made concerning the efficiency of the German aircraft industry, the space devoted to repair work and experimentation, the number of workers in each plant, and their working hours, training etc. Recourse was had to analogies drawn from the British aircraft industry. Finally, and as a supplement to this type of data, nameplates of German planes shot down over Britain were analyzed. The plates usually bore the manufacturer's name, the factory, the plane's serial number, and until 1941, the date of its completion.

Since revisions have been made in the MEW series from time to time, it is not certain whether or not the estimates set forth in Table VI, on page 16, contain any obsolete estimates. And since, too, the OSS Washington's files of MEW estimates suffer certain gaps, these gaps have been filled in by linear interpolation.

Various other estimates have placed German production of tactical planes (excluding transports) at 1750 per month. It will be observed these estimates have been used to bring the MEW estimate, up-to-date for the purpose of certain calculations below. However, attention is drawn to the fact that not only have there been no MEW estimates available since January 1942, but that in the intervening period the MEW, in process of attempting a reconciliation with the Air Ministry's estimates, has suggested that airplane production in Germany had declined some 8 percent.2/

B. Air Ministry AM Estimate

In the spring of 1942, the Air Ministry, after analyzing certain material in its possession, came to the conclusion that the MEW estimates of airplane output were too high. The methods used by the Air Ministry in reaching a new estimate are not set forth, but the manner of presentation suggests that they involve a tabulation of certain aircraft identified to have been produced at certain factories, along with allowance for unidentified production. As of September 1, 1942, the Air Ministry estimated that Germany produced 1195 tactical planes along with 55 unidentified planes per month. On October 1, 1942, the Air Ministry estimated output at 1250 identified planes, along with 50 unidentified, and on the latter occasion, back figures for the five half-year

---

1/ All estimates refer to Greater Germany, the Protectorate, and Poland.

2/ MEW review of January-June 1942.

TABLE VI

OSS Formulation of

M.E.W. Estimate of German Aircraft Production

Date	All Types	Combat Types						
		Total	Long-Range Bomber1/	Dive Bomber	Single Engine Fighter	Twin Engine Fighter	Army Cooper-ation	Coastal
1939								
July	1,050	700	325	75	145	55	50	50
Aug.	1,100	765	345	85	165	60	50	60
Sept.	1,145	820	360	100	180	70	50	60
Oct.	1,195	870	375	110	200	75	50	60
Nov.	1,270	940	400	130	215	80	50	65
Dec.	1,355	1,015	420	160	230	80	50	75
1940								
Jan.	1,400	1,040	400	165	250	100	50	75
Feb.	1,400	1,040	400	165	260	100	50	75
Mar.	1,490	1,085	415	170	270	110	50	80
Apr.	1,555	1,125	430	175	280	120	50	80
May	1,610	1,165	445	180	300	130	50	80
June	1,700	1,230	465	190	280	140	50	85
July	1,610	1,155	440	180	280	120	50	85
Aug.	1,605	1,150	435	180	300	120	50	85
Sept.	1,700	1,230	465	190	300	140	50	85
Oct.	1,760	1,270	480	180	325	145	50	90
Nov.	1,800	1,290	495	170	335	150	50	90
Dec.	1,850	1,320	520	160	340	160	50	90
1941								
Jan.	1,905	1,380	545	160	350	165	60	100
Feb.	1,970	1,410	545	165	365	170	65	100
Mar.	2,135	1,440	545	170	380	175	70	100
Apr.	2,100	1,470	550	175	390	180	75	100
May	2,165	1,500	550	180	400	190	75	100
June	2,220	1,520	555	180	410	195	80	100
July	2,265	1,555	560	185	420	205	85	100
Aug.	2,305	1,580	565	185	430	210	85	105
Sept.	2,350	1,610	570	190	440	215	85	110
Oct.	2,390	1,635	575	190	450	220	85	115
Nov.	2,435	1,670	580	195	460	230	85	120
Dec.	2,485	1,705	590	195	470	240	85	125
1942								
Jan.	2,530	1,730	600	195	480	240	90	125

1/ Including bomber-reconnaissance

(8800)

periods from January 1940, to June 1942, were presented as shown below, and general agreement was expressed with the MEW estimate of 820 tactical planes having been produced during September 1939. Finally on November 1, 1942, the Air Ministry estimated that Germany was producing some 1235 identified, and 50 unidentified aircraft per month.

Average Monthly Production of Combat Planes

Category	Jan. to June 1940	July to Dec. 1940	Jan. to June 1941	July to Dec. 1941	Jan. to June 1942
Long-range Bombers	320	365	370	425	435
Dive Bombers	80	80	70	85	100
S.E. Fighters	280	300	325	360	410
T.E. Fighters	100	120	110	130	130
Miscellaneous	145	150	160	150	155
Total	925	1,015	1,035	1,150	1,230

Since a monthly estimate of airplane output is required for the purposes of this study, the foregoing figures have been broken down into a monthly series, but it is impossible to fit a smooth curve to the data, because the averages move erratically. Hence, the monthly estimates shown in Table VII, on page 18, may not represent the true Air Ministry estimates of German aircraft output, but it will be noted that the total number of planes integrated under the curve is in accord with the stated averages.

C. Other Estimates

Responsibility for estimating enemy airplane output rests in the United States with the Military Intelligence Service (MIS) of the Army, but no continuous series of estimates has been made available by MIS. After circulating single estimates as high as 2,400-2,500 tactical planes (3,000 planes of all types) monthly, MIS is currently believed to credit Germany with an output of 1,750 tactical planes a month, or approximately the same quantity as found in the MEW estimates.

There are few estimates which place German production lower than the Air Ministry.1/ Its estimate may, therefore, be taken as the lowest. On the other hand, a wide number of official and other sources have suggested estimates well above those of MEW and MIS. In light of the fact that one of the contentions of this paper is that the MEW estimate is too high, higher estimates can be considered only if the case against the MEW fails to be substantiated.

1/ An informant in contact with German Army Officers reports German production of combat planes as 900 in the summer of 1942. (Accession 21960-Secret)

TABLE VII

OSS Formulation of the Air Ministry's Estimate of German Combat Aircraft Production 1/

Date	Total	Long Range Bomber 2/	Dive Bomber	Single Engine Fighter	Twin Engine Fighter	Army Cooperation	Coastal	Miscellaneous & Unidentified
1939								
Sept.	820	280	80	250	80	70	45	15
Oct.	840	290	80	255	85	70	45	15
Nov.	855	300	80	260	85	70	45	15
Dec.	870	305	80	265	90	70	45	15
1940								
Jan.	885	310	80	270	90	70	50	15
Feb.	900	315	80	270	95	70	50	20
Mar.	915	320	80	270	100	70	55	20
Apr.	930	325	80	280	100	70	55	20
May	950	325	80	285	110	70	60	20
June	970	335	80	295	110	70	60	20
July	990	345	85	295	115	70	60	20
Aug.	1,015	360	85	300	120	70	60	20
Sept.	1,015	365	80	300	120	70	60	20
Oct.	1,015	365	80	300	120	70	60	20
Nov.	1,020	370	75	305	120	70	60	20
Dec.	1,025	375	75	305	120	70	60	20
1941								
Jan.	1,025	375	75	305	110	70	60	30
Feb.	1,030	375	75	310	110	70	60	30
Mar.	1,035	375	70	325	105	70	60	30
Apr.	1,035	370	70	330	105	70	60	30
May	1,040	370	65	335	110	70	60	30
June	1,045	370	65	335	115	70	60	30
July	1,070	385	70	340	120	70	55	30
Aug.	1,100	405	75	345	120	70	55	30
Sept.	1,135	420	85	355	125	70	50	30
Oct.	1,175	435	90	365	135	70	50	30
Nov.	1,200	445	95	375	135	70	50	30
Dec.	1,210	445	100	380	135	70	45	35
1942								
Jan.	1,220	445	100	390	130	70	45	40
Feb.	1,225	440	100	400	130	70	45	40
Mar.	1,230	435	100	410	130	70	45	40
Apr.	1,230	430	100	415	130	70	45	40
May	1,235	430	100	420	130	70	45	40
June	1,235	430	100	420	130	70	45	40
July	1,240	445	100	415	120	70	45	45
Aug.	1,250	455	100	410	115	70	45	55
Sept.	1,300	500	100	420	115	70	45	50
Oct.	1,285	475	100	440	120	65	35	50

1/ 1939 figures extrapolated to tie to MEW's figure of 820 combat planes in September 1939.

2/ Including Bomber-reconnaissance.

(8800)

D. Production and Wastage

If the monthly series for allocation to training and wastage are compared with the monthly production estimates of the MEW and the Air Ministry, the following development of German planes available for combat is derived.

Net Change in German Aircraft Strength

By Calendar Periods:

	MEW Estimate	AM Estimate
Sept. - Dec. 1939	+ 2,410	+ 2,150
Jan. - Dec. 1940	+ 2,790	+ 320
Jan. - Dec. 1941	+ 3,160	- 2,215
Jan. - Oct. 1942	+ 3,055	- 1,935
Total	+11,415	- 1,680

By Campaigns:

	MEW Estimate	AM Estimate
Sept. 1939 - April 1940	+ 5,450	+ 4,530
April 1940 - Sept. 1940	- 1,665	- 2,655
Oct. 1940 - June 1941	+ 4,935	+ 1,605
July 1941 - Oct. 1941	- 1,480	- 3,380
Nov. 1941 - June 1942	+ 4,295	+ 265
July 1942 - Oct. 1942	- 120	- 2,045
Total	+11,415	- 1,680

The MEW estimate of output, taken in conjunction with the estimates of wastage and allocation to training developed above, leads to the conclusion that planes available for combat have increased 11,415 since the beginning of the war; whereas, the Air Ministry estimate of production in conjunction with the same estimates of wastage gives a net reduction of 1,680 planes. Which is the more appropriate estimate in terms of the actual development of the GAF strength, can only be judged after a preliminary discussion of strength.

IV. STRENGTH

Three types of plane strength are discussed in this study: 1) first-line strength; 2) total strength; and, 3) total planes.

First-line strength embraces planes organized in combat squadrons. Initial equipment of combat squadrons consists of nine planes per squadron, while three additional planes per squadron for immediate reserves are called for in the GAF tables of organization. No effort has been made to analyze or modify first-line strength estimates by the serviceability factor which varies, according to conditions, from 30 percent to 80 percent.

Total strength consists of first-line strength, (that is, initial equipment and immediate reserves) planes in RTU's, stored reserves, and planes in transit from factories to operational squadrons at the front -- a minimum of 300-500 planes under conditions where rates of loss are rather high and where the GAF operates far from airplane factories.

Total planes includes all of the planes in the preceding category, as well as those in OTU's and factory repair pools.

A. Strength Estimates

Basic material relating to German Air Force first-line strength is to be found in the GAF Orders of Battle published by the Air Ministry. The following comments relate to these, and other estimates.

In the Air Ministry's estimates, the quantity of immediate reserves is calculated not by separate squadrons but on an overall basis. At the same time, the British do not consider planes in OTU's, or at repair factories, (including those in transit to, and from such factories) as part of GAF total strength. It is believed that these planes are not available for use, and that OTU's could not be employed in combat except as a desparate measure since their diversion to squadrons would cut off the flow of replacement pilots; a view shared by this study.

MIS, on the other hand, includes both OTU's and planes under repair at factories in its estimates of GAF "strength". The difference in these two estimates may currently amount to 2,500 planes, but it may be observed that this difference rests upon the varying definitions of "total strength." MIS does not attempt to draw a line between this and "total planes."

In the matter of immediate reserves and stored reserves, or reserves in storage depots, considerable variance may be discovered in various estimates. The Air Ministry reckons that immediate reserves may fall below the 30 percent of initial equipment as called for in German table of organization. Its position is based on operational familiarity with the flow of replacements to front-line squadrons, on observations of the strength which the GAF has been able to place in the air over Western Europe and the Mediterranean, and on its knowledge of the rate at which

squadrons have been returned to Central Germany for re-equipment. But MIS, reasoning from its higher estimate for aircraft production, feels that stored reserves must be ample and, therefore, immediate reserves can be kept at full strength.

Tables VIII - XII on the following pages set forth British estimates of German first-line strength, and show breakdowns of initial equipment by types of planes, by theatres, and by types of theatres. Data for the later war period became increasingly more abundant than that for the earlier stage as methods and techniques of estimating improved. (In addition to these lacunae in the earlier period, there are other gaps in the tabulations which result from the incompleteness of OSS' file of Air Ministry data). Corresponding MIS estimates for first-line strength may be calculated if, to the Air Ministry estimates of initial equipment, 30 percent is added for immediate reserves up to tables of organization requirements.

It will be noted that the Air Ministry estimate of first-line strength is a rounded figure. The rounding off of these estimates occurs in connection with appraising the strength of non-operational squadrons located in Central Germany for refitting or re-equipment, about which considerable uncertainly exists. The Air Ministry practice is to assign to each squadron one-third of its initial equipment after it has spent one month in Central Germany; two-thirds after a two-month stay; and full equipment upon the completion of three months, after which the squadron's reappearance in an active theatre may be expected at any moment. Because of the arbitrary character of this assumption, estimates for Central Germany have been increased slightly so as to make totals for each type add to a round figure. MIS, however, increases these allowances by 30 percent, along with initial equipment strength in operational squadrons. This is done not on the grounds that the squadrons have immediate reserves (which they do not have), but in order to provide for possible underestimate involved in this procedure.

B. Strength in Relation to Production and Wastage

The Air Ministry first-line GAF strength estimate for the outbreak of the war and that for September 30, 1942, may be used provisionally to test the reasonableness of the production estimates of the MEW and the Air Ministry, respectively. MEW's estimate of German air-craft output, used in conjunction with the wastage estimates shown previously, indicate an increase in Germany's "total planes" in the period August 31, 1939, to September 30, 1942, of 11,145 units, while the Air Ministry production estimate for the same period and thrown against the same wastage estimates reveals a decrease in "total planes" of 1,485 units. (The tabulation on page 19, suggests comparable figures as of October 31, 1942, but September 30, 1942, estimates have been employed here since these figures for first-line strength are better established).

It is clear that on the basis of MEW's production curve and OSS' estimates for wastage and other requirements, the rise in MEW's

TABLE VIII

Air Ministry Estimate of First-Line
Strength and Initial Equipment by Types

Date	First Line	Initial Equipment: Total	Long Range Bomber	Bomber Recon.	Dive Bomber	Single Engine Fighter	Twin Engine Fighter	Army Coop.	Coastal	Immediate Reserve
1939										
Aug. 31,	4,320	3,250	1,310	280	280	710	200	240	220	1,070
Sept.										
Oct.										
Nov.										
Dec.										
1940										
Feb.										
Mar. 31,	4,900	-	-	-	-	-	-	-	-	-
Apr. 9,	4,900	3,710	1,410	360	370	730	310	270	260	1,190
May 10,	5,400	4,210	1,500	450	400	1,000	280	280	300	1,190
June										
July										
Aug. 8,	5,800	4,430	1,560	450	540	930	430	270	250	1,370
Sept. 30,	4,600	-	-	-	-	-	-	-	-	-
Oct.										
Nov.										
Dec. 31,	5,000	-	-	-	-	-	-	-	-	-
1941										
Jan.										
Feb.										
Mar.										
Apr. 6,	5,730	4,420	1,400	450	480	1,050	450	340	250	1,310
May										
June 22,	5,890	4,540	1,500	430	480	1,050	460	350	270	1,350
July										
Aug. ?	-	4,540	1,500	430	480	1,050	460	350	270	?
Sept. 30,	-	4,550	1,470	460	400	1,050	480	430	260	?
Oct.										
Nov.										
Dec.										
1942										
Jan. 12,	3,820	3,980	1,350	430	300	950	380	380	190	-160
Feb.										
Mar. 14,	4,260	4,260	1,400	460	350	1,070	430	370	180	-
Apr. 13,	-	4,370	1,460	460	370	1,100	420	380	180	-
May 21,	4,800	4,560	1,470	400	430	1,160	460	460	180	240
June 6,	4,800	4,560	1,470	400	430	1,160	460	460	180	240
July 18,	-	4,730	1,450	390	460	1,190	590	470	180	?
Aug. 8,	4,800	4,700	1,460	400	450	1,180	590	430	190	100
Sept. 19,	-	4,740	1,460	400	450	1,200	610	430	190	?
Oct.										
Nov.										
Dec. 5,	3,870	4,510	1,435	380	500 1/	1,105	560	380	150	-640

1/ Including 130 ground attack and anti-tank planes.

(8800)

CHART 3

GERMAN AIRFORCE FIRST LINE STRENGTH

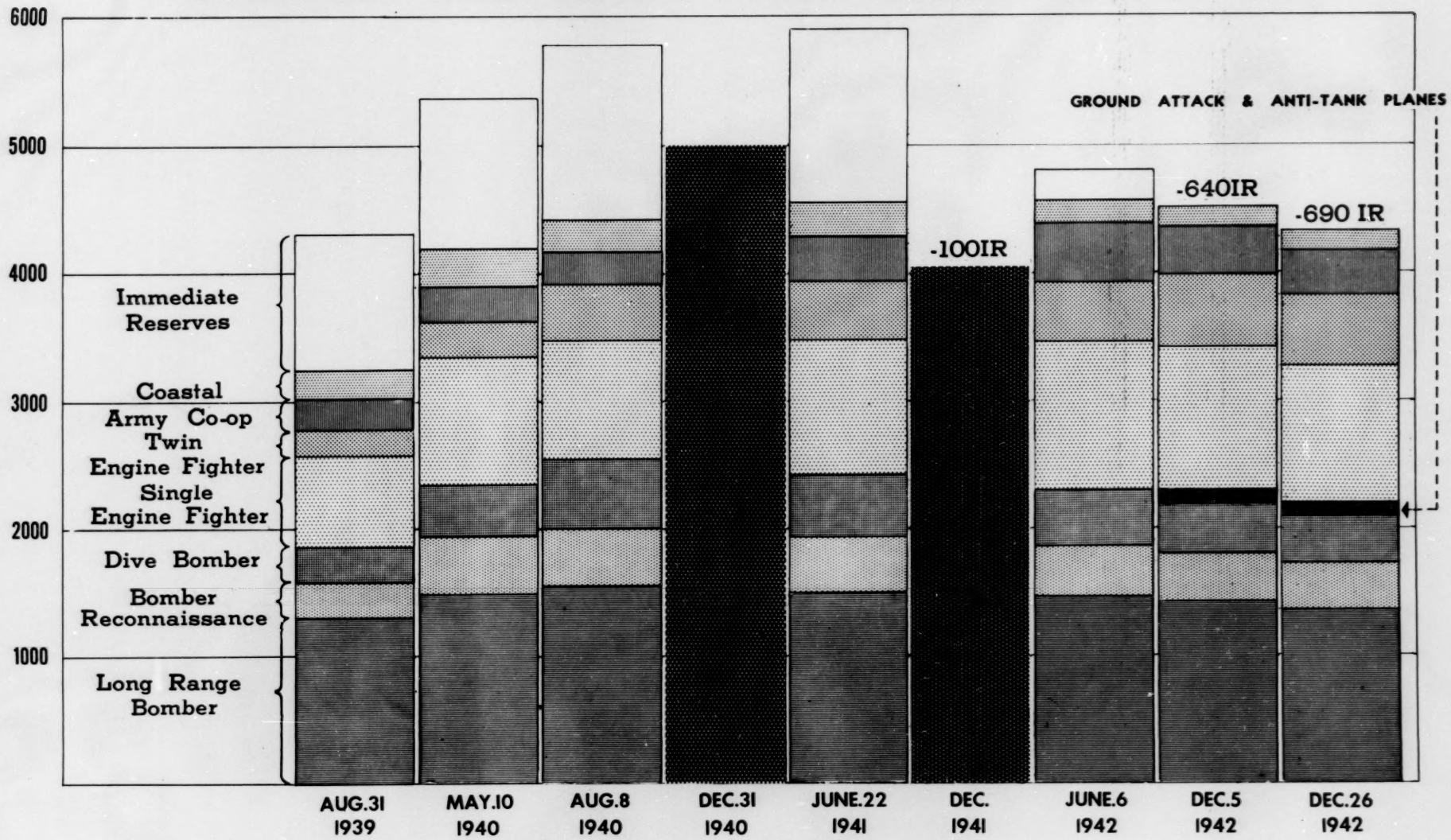


TABLE IX

Air Ministry Estimate of Initial Equipment by Theatres

Date	Total	Poland	Norway	Western Front	Mediter-ranean	Balkans	Russia	Central Germany
1939								
Sept.	3,250	1,360	-	1,580	-	-	-	310
Oct.								
Nov.								
Dec.								
1940								
Jan.								
Feb.								
Mar.								
Apr. 9	3,710	-	810	2,210	-	-	-	690
May 10	4,210	-	320	3,300	-	-	-	590
June								
July								
Aug. 8	4,430	-	350	3,450	-	-	-	630
Sept.								
Oct.								
Nov.								
Dec.								
1941								
Jan.								
Feb.								
Mar.								
Apr. 6	4,420	-	240	2,260	350	1,000	-	570
May								
June 21,	4,540	-	150	1,160	150	240	2,500	340
July ?	-	-	-	-	-	-	2,750	-
Aug. 30	4,540	-	-	-	-	-	2,640	-
Sept. ?	-	-	-	-	-	-	2,167	-
Oct. 31,	4,550	-	-	-	-	-	2,167	-
Nov.	4,550							
Dec.								
1942								
Jan.	3,980	-	-	-	-	-	1,685	-
Feb.	-	-	-	-	-	-	1,640	-
Mar. 14,	4,260	-	-	993	741	-	1,965	541
Apr. 13,	4,370	-	-	999	732	-	2,045	594
May 2,	4,440	-	-	1,107	672	-	1,973	680
June 6,	4,570	-	-	1,166	600	-	2,427	377
July 18,	4,730	-	-	1,212	717	-	2,544	257
Aug. 8,	4,700	-	-	1,242	663	-	2,460	335
Sept. 30	4,740	-	-	1,198	714	-	2,528	300
Oct.								
Nov.								
Dec. 5,	4,510	-	-	1,068	1,186	-	2,034	222

TABLE X

Air Ministry Estimate of Initial Equipment
Western Front

Date	Total	Long Range Bomber	Bomber Recon.	Dive Bomber	Single Engine Fighter	Twin Engine Fighter	Army Coop.	Coastal
1939								
Sept. 1,	1,580	630	130	90	450	60	50	170
Oct.								
Nov.								
Dec.								
1940								
Jan.								
Feb.								
Mar.								
Apr. 9,	2,210	850	200	210	520	170	160	100
May 10	3,300	1,280	360	270	770	220	230	170
June								
July								
Aug. 8,	3,450	1,270	290	480	720	340	200	150
Sept.								
Oct.								
Nov.								
Dec.								
1941								
Jan.								
Feb.								
Mar.								
Apr. 6,	2,260	900	240	60	680	160	160	60
May								
June 22,	1,160	310	90	60	300	230	20	150
July								
Aug.								
Sept.								
Nov.								
Dec.								
1942								
Jan.								
Feb.								
Mar. 14,	993	255	93	18	357	177	9	84
Apr. 13,	999	243	78	18	377	189	-	94
May 2,	1,107	279	81	18	416	210	-	103
June 6,	1,166	345	78	18	395	248	-	84
July								
Aug. 8,	1,242	348	93	18	402	288	-	93
Sept.								
Oct.								
Nov.								
Dec. 5,	1,068	198	96	9	327	354	9	75

TABLE XI

Air Ministry Estimate of Initial Equipment
Eastern Front

Date	Total Estimated	Total Identified	Long Range Bomber	Recon. Bomber	Dive Bomber	Single Engine Fighter	Twin Engine Fighter	Army Coop.	Coastal
1939									
Sept.	-	1,360[1]	590	120	140	200	120	160	30
Oct.									
Nov.									
Dec.									
1940									
Jan.									
Feb.									
Mar.									
Apr.									
May									
June									
July									
Aug.									
Sept.									
Oct.									
Nov.									
Dec.									
1941									
Jan.									
Feb.									
Mar.									
Apr.									
May									
June 22,	-	2,500	880	230	240	680	150	280	40
July 31,	2,750	2,406	1,000	201	240	650	120	135	50
Aug. 31,	2,640	2,500	-	-	-	-	-	-	-
Sept. 30,	2,575	2,430	1,020	216	252	552	105	234	53
Oct. 31,	2,167	1,970	700	253	186	465	40	270	56
Nov.									
Dec.									
1942									
Jan. ?		1,685	640	180	130	360	70	270	35
Feb. ?		1,640	-	-	-	-	-	-	-
Mar. 14,		1,965	657	243	231	402	129	288	15
Apr. 13,		2,045	738	270	231	405	90	297	14
May 2,		1,973	741	255	261	414	9	279	14
June 6,		2,427	819	210	321	531	99	414	33
July									
Aug. 8,		2,460	759	213	321	525	231	387	24
Sept.									
Oct.									
Nov.									
Dec. 5,		2,034	609	195	333[2]	459	90	324	24

1/ Polish Campaign.
2/ Including 63 ground attack and anti-tank planes.

(8800)

TABLE XII

Air Ministry Estimate of Initial Equipment
Mediterranean Theatre

Date	Total	Long Range Bomber	Recon. Bomber	Dive Bomber	Single Engine Fighter	Twin Engine Fighter	Army Coop.	Coastal
1939								
Sept.								
Oct.								
Nov.								
Dec.								
1940								
Jan.								
Feb.								
Mar.								
Apr.								
May								
June								
July								
Aug.								
Sept.								
Oct.								
Nov.								
Dec.								
1941								
Jan.								
Feb.								
Mar.								
Apr. 9,	1,350 1/	330	100	360	310	100	130	20
May								
June 22,	390	150	40	90	30	40	20	20
July								
Aug.								
Sept.								
Oct.								
Nov.								
Dec.								
1942								
Jan.								
Feb.								
Mar. 14,	741	270	69	60	222	75	9	36
Apr. 13,	-	246	69	90	222	60	9	36
May 2,	672	243	63	60	192	60	18	36
June 6,	600	195	57	78	165	60	9	36
July								
Aug. 8,	663	243	69	81	195	30	9	36
Sept.								
Oct.								
Nov.								
Dec.5,	1,186	565	75	117 2/	288	96	27	18

1/ Concentrated in the Balkans for the Greek campaign.
2/ Including 48 ground attack and anti-tank planes.

estimated GAF first-line strength between August 1939, and September 1942, from 4,320 to 4,700 planes, (in addition to an increase of 300 planes in RTU's not already allowed for under "allocations to training") should have been accompanied by an increase in "stored reserves" and "planes under repair at factories" totaling 10,465. But this is patently an unfeasible figure since the highest of all estimates of stored reserves for September 1942, is that of MIS of approximately 2,900 planes, which includes planes under repair.1/ If the OSS estimates of wastage and allocations to training are accepted, then it must be concluded that MEW production estimates are too high.

On the other hand, and accepting the OSS estimate of wastage and other requirements, the Air Ministry production estimate must be considered too low. For if, as mentioned above, the Air Ministry output estimate indicates a decline in "total planes" of 1,485 in the period August 1939-September 1942, then stored reserves at the beginning of the war would have had to have been 3,665. (This last-named figure is arrived at by adding the increase of 380 in first-line strength, the increase of 300 in RTU's, the increase of 1,000 in planes under repair at factories, and a minimum of 500 planes in stored reserves or in transit on September 30, 1942, and the decline of 1,485 in total plane strength). But it is known that Germany, at the outbreak of the war in 1939, put what proved to be an unduly large proportion of its planes into first-line strength at the expense of stored reserves. Moreover, such planes in first-line use in Poland as the single-engine fighter Heinkel 51 were obsolescent in view of the Messerschmidt 109 which had been introduced almost completely into combat squadrons. Both the evidence and informed opinion point to the fact that stored reserves at the outbreak of World War II were low, and far from the implied Air Ministry figure of 3,665.

In its production estimate for October 1, 1942, the Air Ministry, after suggesting figures for the earlier periods of the war, (see page 19), remarks that these production series agree fairly well with estimates of wastage and strength. But it appears certain, however, any final test of Air Ministry's production estimate cannot be tested against the OSS wastage estimate in light of the fact that the Air Ministry's wastage estimate is so much lower.

The Air Ministry, it has been learned, estimates "stored reserves" at 1,500 planes as of June 30, 1941, 500 planes as of December 31, 1941, and 750 planes as of June 30, (and September 30, 1942). Its residually derived wastage and allocations-to-training estimates amount to 13,000 planes for the year ending June 30, 1942. Comparing the Air Ministry's 13,000 figure to this study's wastage and allocations-to-training estimate of 17,380 for the same period, it should be noted that the discrepancy between the two estimates of 365 planes per month may lie in the German wastage rate on the Eastern Front, which is difficult to measure by any method.

1/ Cf. "Situation and Capabilities of the Enemy," September 17, 1942. A subsequent figure, in a November issue, estimates stored reserves at 21,170 planes.

(8800)

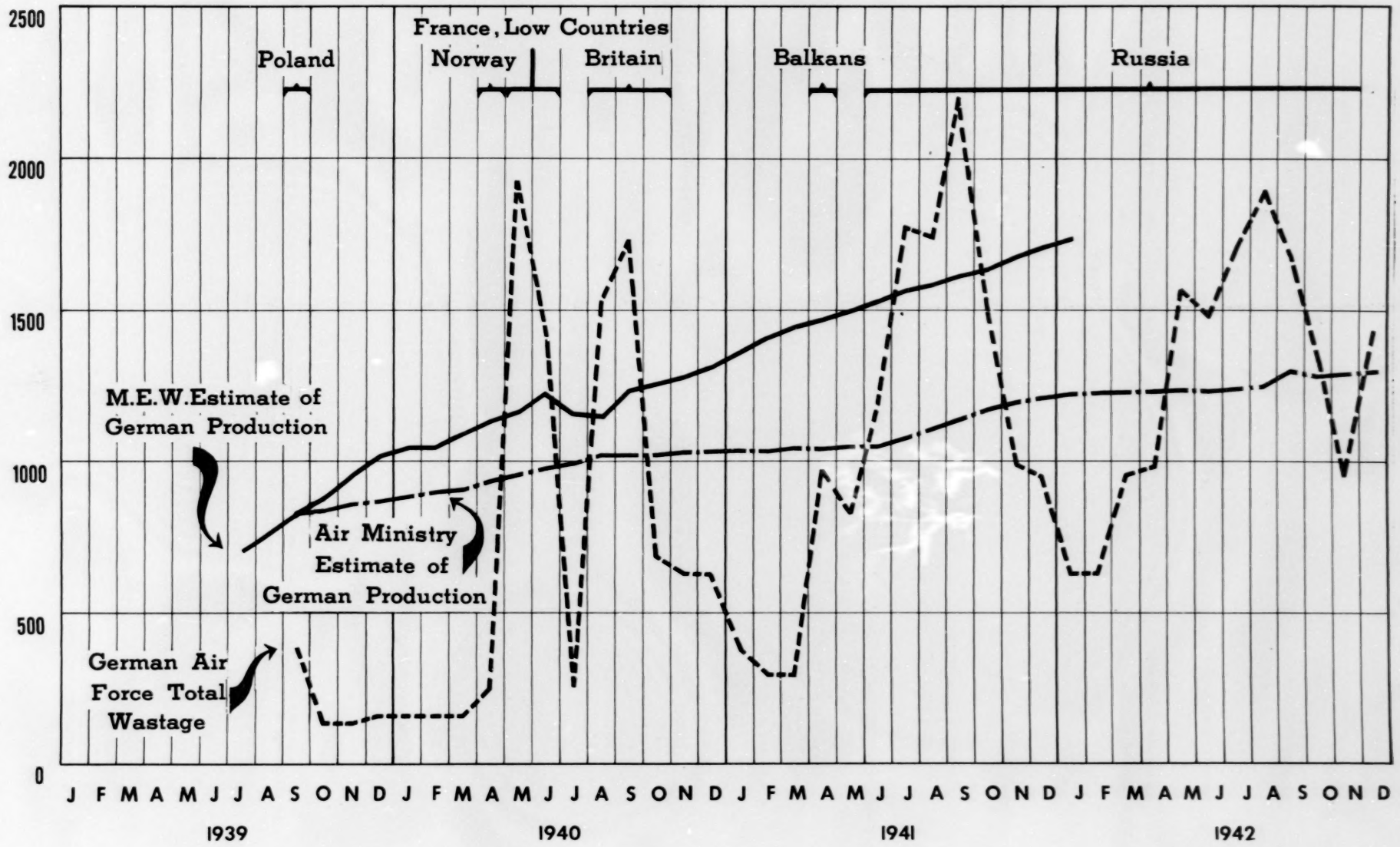
However, the Air Ministry conclusions may be questioned in another regard. Its low-point in first-line strength and the minimum of stored reserves coincide in its estimates of December 31, 1941. Yet air activity in the east fell off sharply in November and December 1941, from the levels of the two preceding months, and squadrons had been withdrawn in December for transfer to other theatres or for purposes of rest and refitting. There is little doubt that wastage in November and December must have fallen below the level of production in those months. Thus, if first-line strength was reduced by about 350 planes between October 31, and December 31, 1941, and stored reserves were at their minimum of 500 on October 31, stored reserves two months later must have been at least 850 plus the increment of production over wastage during November and December.

A similar discrepancy in timing appears in the Air Ministry estimates both for wastage and strength in the fall of 1942. Accompanying the production estimates distributed monthly by the Air Ministry beginning September 1, 1942, are wastage estimates which arrive at the conclusion that production and wastage (including other requirements) were practically in balance during August, September, and October. The estimate of strength for December 7, however, shows a slight decline in the total numbers of squadrons in the GAF, and a reduction of strength below initial equipment estimated at 20 percent in the Russian and Mediterranean theatres. Since German losses on the Eastern Front declined sharply in November from the level reached in August and September, as measured by Russian admissions of their own losses, Russian claims of German losses, or German admissions, or as may be concluded from a study of the intensity of operations, it is most unlikely that total German losses exceeded production in November. If the December estimate of strength is accepted, it appears that the Air Ministry has been slow in recognizing the decline in strength, and that the estimate of wastage for August and September are too low.

Another question may be raised in relation to the Air Ministry's estimate of 1,500 stored reserves at June 30, 1941. According to responsible reports, the GAF was at its greatest strength with respect to reserves in May and June 1941, previous to the attack upon Russia. This is a reasonable position in light of the relatively low-scale use of fighters, dive-bombers and army cooperation planes after the second month of the Battle of Britain, and in view of the lessons regarding loss and the necessity for maintaining reserves in the rear drawn by the GAF from 20 months of warfare. But the Air Ministry figure of 1,500 stored reserves, if correct, would indicate that those reserves amounted to less than one-third of first-line strength or, if lumped together with RTU's to slightly more than one-third. While it may be argued that the GAF, now on the defensive in western Europe, the Mediterranean, and the Russian front is weak, it does not deflect from the view that the original offensive against Russia would not have been undertaken unless stored and other reserves more closely approached the standard 1:1 ratio to first-line strength than is implied by the Air Ministry estimate.

CHART 4

WASTAGE COMPARED with PRODUCTION


2500
2000
1500
1000
500
0
Poland
France, Low Countries
Norway
Britain
Balkans
Russia
M.E.W. Estimate of German Production
Air Ministry Estimate of German Production
German Air Force Total Wastage
J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D
1939
1940
1941
1942

The MIS overall estimate of GAF "total planes" strength of 11,000 planes is a rather insensitive one, failing to reflect changes in the net of production and wastage and other requirements.

1942	Total Combat Planes	No. of Squadrons	Planes in Operating Squadrons	RTU's	OTU's	Others 1/
Sept. 12,	11,015	(459)	6,063	550	1,500	2,902
" 26,	11,000	(466)	6,150	550	1,500	2,800
Oct. 10,	11,000	(469)	6,200	550	1,500	2,750
Nov. 10,	10,000	(482)	5,780	550	1,500	2,170

The question of whether or not immediate reserves exist in operating squadrons is one which can be settled by operational intelligence and reports from prisoners of war. While there is reason to believe that some squadrons are at times up to full strength, there are plenty of contrary indications suggesting that the level of immediate reserves fluctuates widely, reaching close to zero or even below it (viz. squadrons averaging even less than nine planes of initial equipment), after prolonged periods of high activity.

When the MEW production estimate, and the OSS wastage and other requirements estimate are thrown against the latest MIS "total planes" strength, it appears that the GAF must have started the war with fewer than 1500 planes. This is derived from the fact that output less wastage has amounted to 11,415 planes, and current strength, excluding OTU's, is estimated by MIS to be only 8,500 although MIS may hold the view that German aircraft production prior to the present period was lower than that indicated by the MEW, the fact remains that most separate and distinct MIS production estimates have been higher. It is probable that MIS employs a higher wastage rate than the one used in this study, but nothing is known as to the manner or method MIS uses to establish it.

MIS strength estimates may be finally tested by the evidence of GAF strength in field of battle. And on this basis, and in light of the admissions of Hitler, Goering, and Goebbels, it must be doubted that the GAF is as comfortably situated with respect to immediate and stored reserves as MIS figures may imply.

1/ The category "others" includes planes sent from factories to depots for adjustments, and planes requiring new installations or repairs, and other unattached planes.

(8800)

V. AN OSS PATTERN OF PRODUCTION, LOSSES, AND STRENGTH

A. Production

This study has not been designed to present an estimate of German aircraft production based upon research into factory capacity, as is that of the MEW, nor on other methods, such as those developed by the Air Ministry. (According to OSS's estimate of wastage and other requirements, the factory capacity method (MEW) credits Germany with too many planes, while the Air Ministry device awards the Germans with too few aircraft!). Instead of relying upon these techniques, the following pages suggest a deductive production curve constructed on statistical foundations which, unrelated to the mass of intelligence both operational and engineering, perhaps shows a better fit to the data on wastage and strength. The relation of this hypothetical curve to the cold reality of types and models is indicated in Table XIII, on page 31.

It is perhaps rash to construct a hypothetical curve in the fact of the tabulated production series published by the Air Ministry and shown on page 19 of this paper. A word may be offered in way of explanation. It will be recalled by referring to the above-mentioned tabulation that the Air Ministry implied that at no time had its production series changed from month-to-month by so much as 50 planes. The averages for the six-month periods were too close together to permit much leeway for month-to-month variations unless it is assumed that wide monthly fluctuations just happened to cancel out. Yet it can be seen that the estimate for October 1, 1942, was 50 planes higher than that for September 1, 1942. From this it may be inferred that the range of error is somewhat wider than that indicated by the allowance for miscellaneous and unidentified planes.

This, and the fact that the Air Ministry's method of estimating has been developed only recently, have led to the conclusion that while Air Ministry figures may be accepted for the present period, its data for the earlier period may be supplemented and supplanted.

The OSS deductive curve leans heavily upon the principle that after development work in a new industry has been completed and production models have been agreed upon, expansion is rapid in the subsequent stage of mass production, but that the rate of expansion thereafter tapers off sharply as production approached the upper limits. The aptness of this principle is best illustrated at a time when expansion is taking place in many fields, as in the armament industries in the United States at present, and those of Germany in 1939-1940.

The curve has been drawn to reach its high point in the fall of 1941 with a decline thereafter, after the comb-outs for the Army in

TABLE XIII

Breakdown of OSS Estimate of
Combat Plane Production by Types

Date	Total	Long Range Bomber	Dive Bomber	Single Engine Fighter	Twin Engine Fighter	Army Cooperation	Coastal
1939							
Sept.	700	210	80	210	85	60	55
Oct.	750	230	90	220	90	65	55
Nov.	800	240	100	240	95	65	60
Dec.	850	260	110	255	100	65	60
1940							
Jan.	900	270	120	275	105	65	65
Feb.	950	300	125	285	110	65	65
Mar.	990	320	130	285	115	70	70
Apr.	1,030	340	135	290	120	70	75
May	1,070	360	140	295	125	70	80
June	1,100	370	145	300	130	70	85
July	1,120	385	145	305	130	70	85
Aug.	1,140	390	145	310	135	70	90
Sept.	1,160	400	145	315	140	70	90
Oct.	1,175	410	145	315	145	70	90
Nov.	1,190	415	145	320	150	70	90
Dec.	1,200	425	140	320	150	75	90
1941							
Jan.	1,200	430	140	320	145	75	90
Feb.	1,200	435	135	325	140	75	95
Mar.	1,200	435	130	330	135	75	95
Apr.	1,210	440	125	345	130	75	95
May	1,230	445	120	365	130	75	95
June	1,250	455	115	385	125	75	95
July	1,270	460	115	400	125	75	95
Aug.	1,285	480	110	405	120	75	95
Sept.	1,295	495	105	410	120	75	90
Oct.	1,305	505	100	415	120	75	90
Nov.	1,310	510	105	415	115	75	90
Dec.	1,315	510	105	415	120	75	85
1942							
Jan.	1,315	515	105	415	120	75	85
Feb.	1,310	520	105	410	115	75	85
Mar.	1,310	520	105	415	115	70	85
Apr.	1,305	510	110	415	115	70	85
May	1,305	515	110	410	115	70	85
June	1,305	525	110	405	110	70	85
July	1,300	535	110	400	105	70	80
Aug.	1,300	540	110	400	100	70	80
Sept.	1,300	545	110	400	95	70	80
Oct.	1,290	545	110	395	95	70	75
Nov.	1,290	550	110	395	90	70	75

TABLE XIV

Development of German Air Force Strength

Date	Airplane Production (OSS)	Allocation to Training	Wastage	Net Change	Strength 1/	Factory Repair Pool 1/	Planes Available
1939							
Aug.					4,600	-	4,600
Sept.	700	80	375	+245	4,845	100	4,745
Oct.	750	125	125	+500	5,345	150	5,195
Nov.	800	125	125	+550	5,895	75	5,820
Dec.	850	130	150	+570	6,465	75	6,390
1940							
Jan.	900	135	150	+615	7,080	100	6,980
Feb.	950	135	150	+665	7,745	100	7,645
Mar.	990	140	150	+700	8,445	100	8,345
Apr.	1,030	140	250	+640	9,085	125	8,960
May	1,070	145	1,925	-1000	8,085	650	7,435
June	1,100	150	1,400	-450	7,635	1,000	6,635
July	1,120	145	250	+725	8,360	875	7,485
Aug.	1,140	160	1,525	-545	7,815	1,125	6,690
Sept.	1,160	170	1,725	-735	7,080	1,450	5,630
Oct.	1,175	175	675	+325	7,405	1,400	6,005
Nov.	1,190	180	625	+385	7,790	1,350	6,440
Dec.	1,200	185	625	+390	8,180	1,275	6,905
1941							
Jan.	1,200	190	375	+635	8,815	1,100	7,715
Feb.	1,200	195	300	+705	9,520	900	8,620
Mar.	1,200	200	300	+700	10,220	700	9,520
Apr.	1,210	210	975	+ 25	10,245	650	9,595
May	1,230	215	825	+190	10,435	575	9,860
June	1,250	165	1,250	-165	10,270	600	9,670
July	1,270	165	1,775	-670	9,600	800	8,800
Aug.	1,285	165	1,750	-630	8,970	950	8,020
Sept.	1,295	165	2,200	-1070	7,900	1,150	6,750
Oct.	1,305	165	1,475	-335	7,565	1,175	6,390
Nov.	1,310	165	975	+170	7,735	1,075	6,660
Dec.	1,315	165	950	+200	7,935	1,000	6,935
1942							
Jan.	1,315	165	625	+525	8,460	800	7,660
Feb.	1,310	165	675	+470	8,930	625	8,305
Mar.	1,310	165	950	+195	9,125	500	8,625
Apr.	1,305	165	975	+165	9,290	525	8,765
May	1,305	165	1,575	-435	8,855	700	8,155
June	1,305	165	1,475	-335	8,520	825	7,695
July	1,300	110	1,700	-510	8,010	950	7,060
Aug.	1,300	105	1,900	-705	7,305	1,025	6,280
Sept.	1,300	150	1,675	-525	6,780	1,075	5,705
Oct.	1,290	155	1,325	-190	6,590	1,025	5,565
Nov.	1,290	155	950	+495	7,085	875	6,210

1/ End of month.

the East had had their full effect.1/ However, the decline is only slight, and serves to bring the curve to the level of the Air Ministry estimate of October 1, 1942. Production is assumed to be increasing at its maximum absolute rate at the outbreak of the war in September 1939, the gain in output for each month being 50 planes.

The smoothed curve used as a production "estimate" is shown in Table XIV, on page 32. The chart on the page following the table compares this with the MEW and Air Ministry estimates, the latter in the form of monthly tabulations prepared by OSS.

B. Wastage and Strength

Using the OSS production curve, and its estimates for wastage and allocations-to-training, series for the net monthly GAF resources may be set forth. If stored reserves are assumed to have been at a minimum at the outbreak of the war, or 280 planes, or a total of first-line and stored reserves of 4,600 planes, a monthly series of figures for first-line strength may be computed, as of the end of each month. If planes under repair at factories are deducted, the result is a category of "total planes available for combat." It should be clear, of course, that this category includes non-operational planes that belong to squadrons being refitted in Germany, and planes in stored reserves and in transit, and such planes as are temporarily unserviceable because of maintenance or repair work being done in forward echelons. (See Table IV)

C. Distribution of Strength

"Total planes available for Combat" is distributed among first-line planes, including initial equipment and immediate reserves, RTU's and "stored reserves and in transit" categories in Table XV, on page 34. Because of the gaps in available Air Ministry first-line strength estimates, wide-scale resort to interpolation was made on a fairly arbitrary basis. Difficulties were experienced at some points, such as proportioning reserves from February 1, to June 1941.

The reasonableness of the development of stored reserves as revealed in the production and wastage estimates is the measure of the reasonableness of the picture of overall plane resources. The stored reserves are seen to grow from the outbreak of the war to a peak in April 1940, while first-line strength and OTU's are expanding similarly.

1/ It may be argued that the airplane industry enjoyed a high priority and would not be affected by comb-outs. On the other hand, additional skilled personnel was required by the GAF, in connection with the attack on Russia, for maintenance and repair work at new factories in the east and at new airfields. The increase in the area over which the GAF operated would alone have required more skilled mechanics, quite aside from the growth in operational squadrons and activity.

TABLE XV

Distribution of German Combat-Type Planes

Date (End of Month)	Grand Total	Total Available for Combat	First Line	Initial Equip.	Immediate Res.	R.T.U.	Stored Res. & in transit	O.T.U.	Factory Repair Pool
1939									
Aug.	5,600	4,600	4,320	3,250	1,070	-	280	1,000	-
Sep.	5,845	4,745	4,400	3,320	1,080	-	345	1,000	100
Oct.	6,385	5,195	4,480	3,390	1,090	-	715	1,040	150
Nov.	6,975	5,820	4,560	3,450	1,110	-	1,260	1,080	75
Dec.	7,585	6,390	4,640	3,510	1,130	-	1,750	1,120	75
1940									
Jan.	8,240	6,980	4,720	3,570	1,150	-	2,260	1,160	100
Feb.	8,945	7,645	4,800	3,630	1,170	-	2,845	1,200	100
Mar.	9,685	8,345	4,900	3,710	1,190	-	3,445	1,240	100
Apr.	10,365	8,960	5,400	4,210	1,190	-	3,560	1,280	125
May	9,405	7,435	5,600	4,400	1,200	-	1,835	1,320	650
June	8,995	6,635	5,600	4,400	1,200	-	1,035	1,360	1,000
July	9,470	7,485	5,800	4,430	1,370	300	1,385	1,110	875
Aug.	8,965	6,690	5,200	4,430	770	330	1,160	1,150	1,125
Sep.	8,280	5,630	4,600	4,400	200	360	670	1,200	1,450
Oct.	8,655	6,005	4,600	4,400	200	390	1,015	1,250	1,400
Nov.	9,090	6,440	4,800	4,400	400	420	1,220	1,300	1,350
Dec.	9,530	6,905	5,000	4,400	600	450	1,455	1,350	1,275
1941									
Jan.	10,215	7,715	5,230	4,400	830	480	2,005	1,400	1,100
Feb.	10,970	8,620	5,470	4,400	1,070	510	2,640	1,450	900
Mar.	11,720	9,520	5,730	4,420	1,310	540	3,250	1,500	700
Apr.	11,795	9,595	5,760	4,420	1,340	570	3,265	1,550	650
May	12,035	9,860	5,800	4,420	1,380	600	3,460	1,600	575
June	11,870	9,670	5,890	4,540	1,350	600	3,180	1,600	600
July	11,200	8,800	5,800	4,540	1,260	600	2,400	1,600	800
Aug.	10,570	8,020	5,350	4,540	810	600	2,070	1,600	950
Sep.	9,500	6,750	4,550	4,540	10	600	1,600	1,600	1,150
Oct.	9,165	6,390	4,400	4,500	-100	600	1,390	1,600	1,175
Nov.	9,335	6,660	4,250	4,350	-100	600	1,815	1,600	1,075
Dec.	9,535	6,935	4,050	4,150	-100	600	2,285	1,600	1,000
1942									
Jan.	10,060	7,660	4,100	4,100	-	600	2,960	1,600	800
Feb.	10,530	8,305	4,200	4,200	-	600	3,505	1,600	625
Mar.	10,725	8,625	4,320	4,320	-	600	3,705	1,600	500
Apr.	10,890	8,765	4,460	4,370	90	600	3,785	1,600	525
May	10,455	8,155	4,800	4,560	240	600	2,755	1,600	700
June	10,120	7,695	4,800	4,570	230	600	2,295	1,600	825
July	9,560	7,060	4,800	4,730	70	600	1,660	1,550	950
Aug.	8,780	6,280	4,700	4,700	-	550	1,040	1,500	1,000
Sep.	8,255	5,705	4,425	4,700	-275	550	730	1,500	1,050
Oct.	8,065	5,565	4,200	4,590	-390	550	815	1,500	1,000
Nov.	8,585	6,210	4,460	4,510	- 50	650	1,100	1,500	875

(8800)

CHART 5

ESTIMATED GERMAN COMBAT AIRCRAFT PRODUCTION

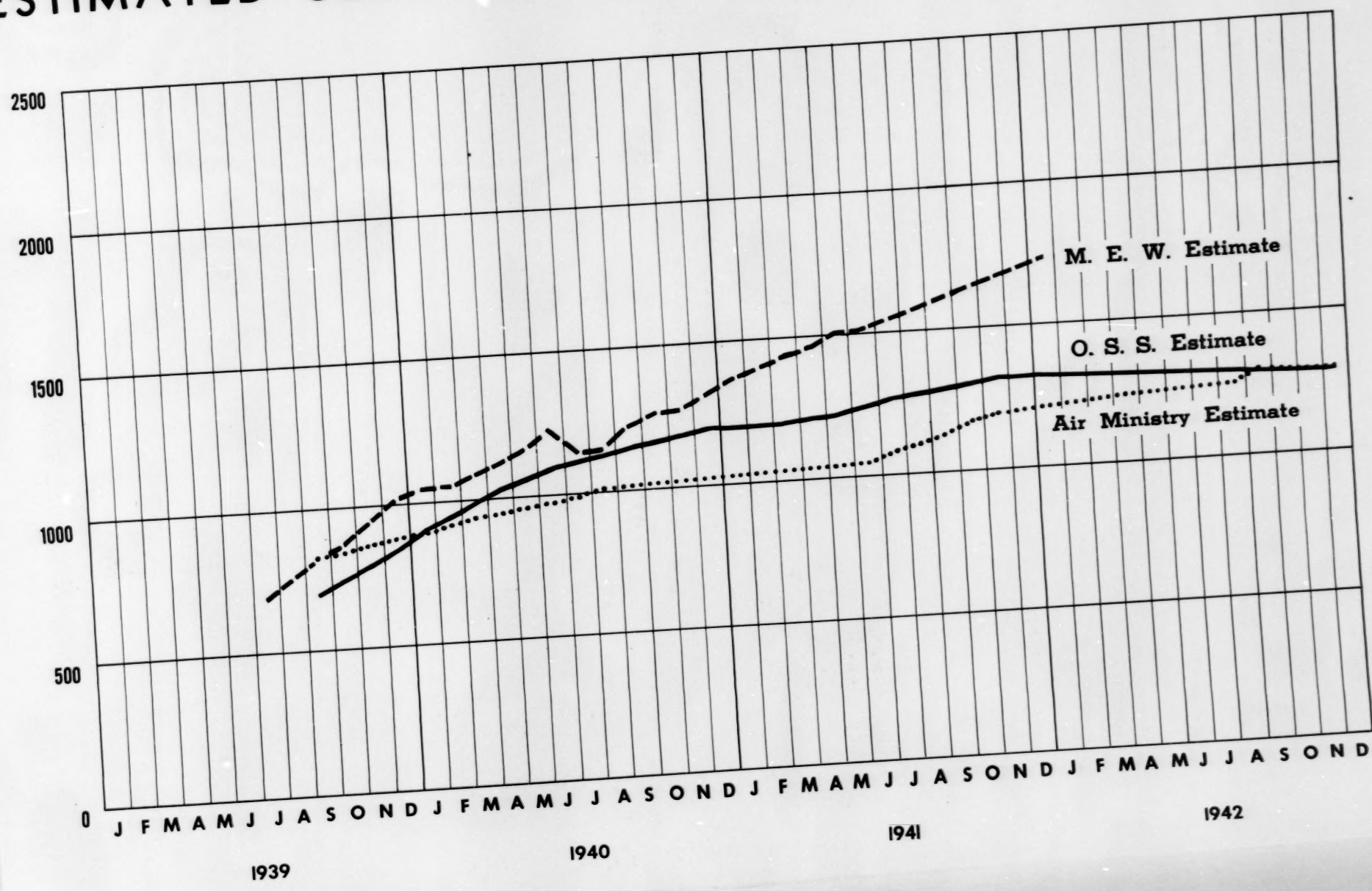

2500
2000
1500
1000
500
0
M. E. W. Estimate
O. S. S. Estimate
Air Ministry Estimate
J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D
1939
1940
1941
1942

CHART 6

WASTAGE COMPARED with PRODUCTION

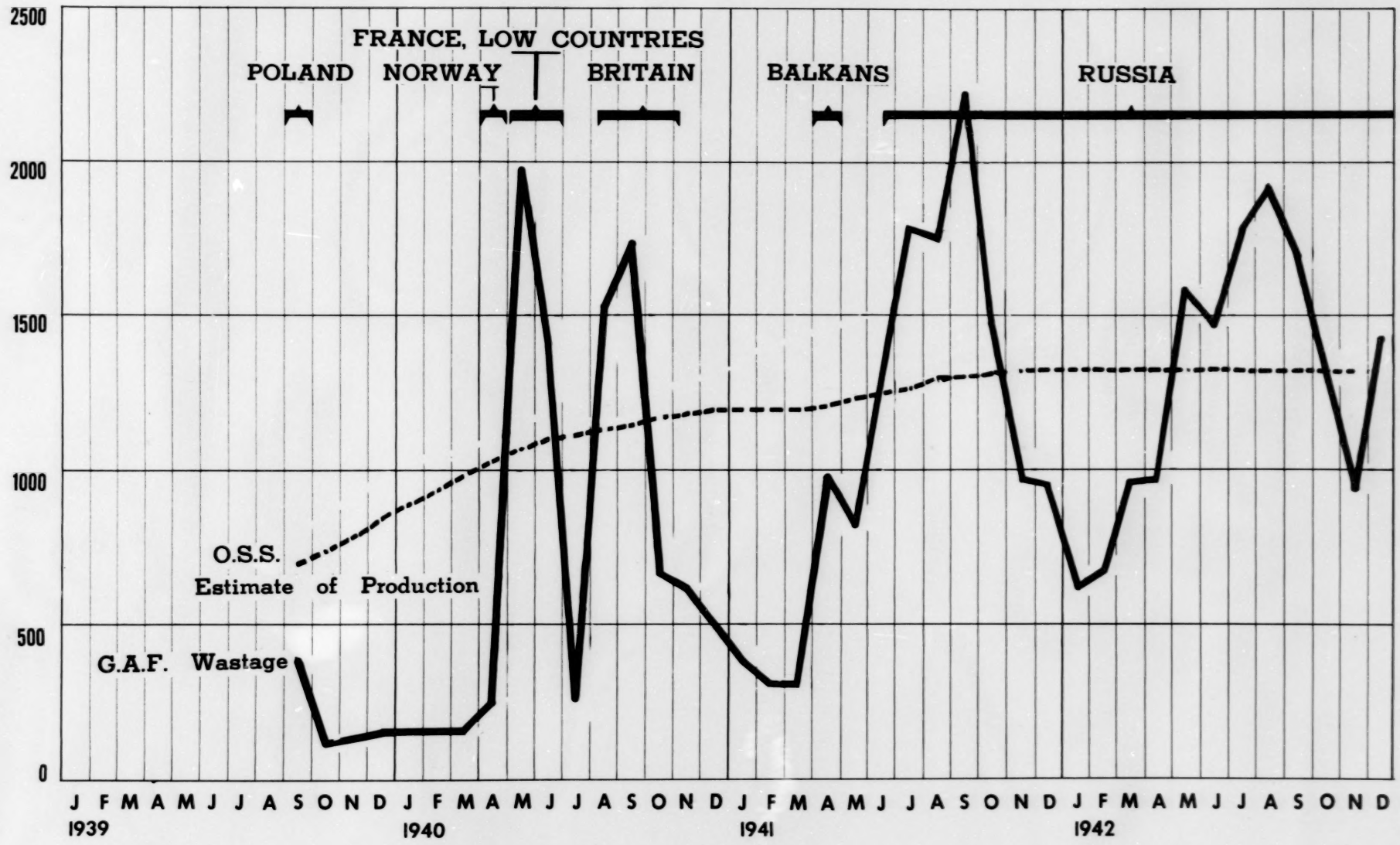
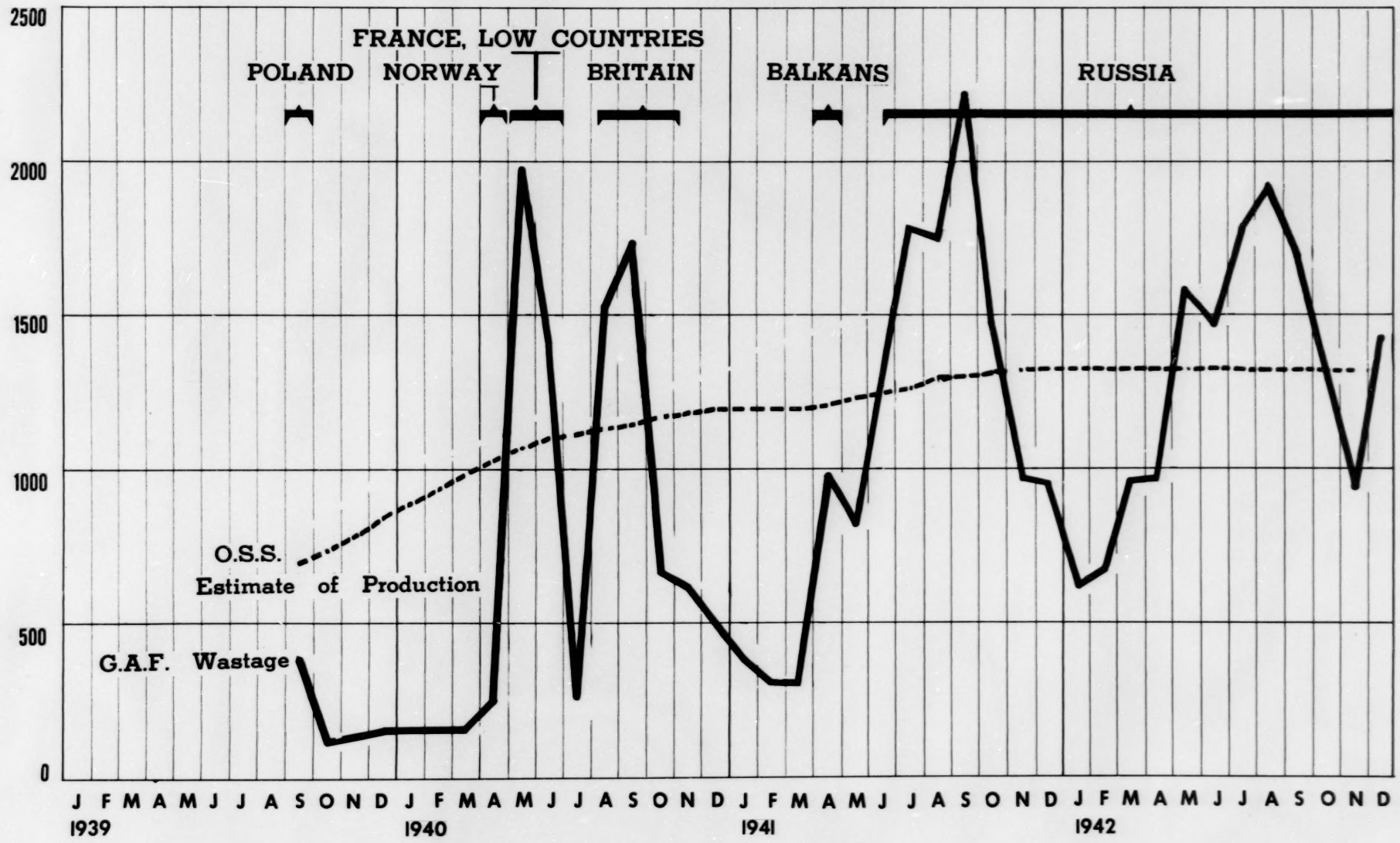


CHART 6

WASTAGE COMPARED with PRODUCTION



A rapid decline sets in with the Battle of Flanders and a low point is reached in September 1940, with the Battle of Britain -- although it may not be low enough.1/

Thereafter the quantity of stored reserves rises until a peak is reached in the Spring of 1941 before the attack upon the Soviets, at which time, too the total resources of GAF have reached their peak. Losses over the Eastern Front, however, them reduce stored reserves to a second low level by the end of October 1941. This depletion is partly restored by April 1942, when the resumption of the Russian campaign is reflected in the downward trend of the stored reserves. Wastage of an intense degree in Russia and in Western Europe, the latter attributable to the Dieppe raid, fighter sweeps, and Flying Fortress attacks, brings the level of stored reserves down to a minimum by the end of September 1942.

It is believed that the results presented in Tables XIV and XV, which have taken into account the whole body of available intelligence regarding production and wastage, as well as strength, are likely to be a more accurate indication of the actual fluctuations of German air strength than other estimates which have been constructed on a narrower basis.

1/ It might be argued, of course, that losses in flying personnel rather than in aircraft was the occasion for the Luftwaffe breaking off of its daylight attacks on Britain in September 1940.

(8800)

APPENDIX I. GERMAN AIRCRAFT PRODUCTION BY TYPES AND MODELS 1/

The main portion of this study presented a smooth curve of German aircraft production which is better adapted to the OSS series of losses and strength than the divergent estimates of the Air Ministry or the Ministry of Economic Warfare.

The following appendix consists of a breakdown by types and models of the above overall production estimate. Its intentions are more to emphasize certain inconsistencies in the Air Ministry's and the MEW's estimates and to indicate possible resolutions of such inconsistencies than to "prove or justify" the previously mentioned OSS overall estimates.

No new material has been available against which the Air Ministry or MEW figures could be judged. In fact, full data for British estimates have been so scanty that considerable interpolation has been necessary to derive a complete series of monthly estimates.

1. Single-Engine Fighters. Differences in the production estimates of the Me.109 account for much of the discrepancy between the overall 1942 estimates of the Air Ministry and those of the MEW.

Chart I shows graphically that while the two estimates were in approximate agreement for the middle of 1940, the Air Ministry production curve presumably started at a higher level in September 1939, than did that of the MEW, only to rise at a slower rate. After mid-1940, however, the MEW production estimate accelerates far more rapidly than does the Air Ministry's curve.

The OSS estimate, it will be seen, runs parallel to, but slightly higher than the MEW estimate for the first eight months of the war (September 1939-April 1940). Thereafter, and until early in 1941, it runs parallel to, but somewhat higher than the Air Ministry's estimate. At the last-named date, and thenceforward, the Air Ministry's figures are consistently lower than those of the MEW.

The approximation of the OSS estimate to the Air Ministry's curve is based on one fact and two assumptions;, 1) it is known that the Me.109 had gone into mass production late in 1938 or early in 1939; 2) it is assumed that the output of this model was still expanding when war broke out in September 1939; and, 3) it is supposed that the total production levelled off in the winter of 1940-41 when production of the Me.109E

1/ A plane type refers to the class in which an aircraft belongs, viz, single-engine fighter, long-range bomber, etc. A plane model signifies the particular plane designs within a type, namely, Messerschmidt 109, Junkers 88, etc. By series or version is meant the various sub-divisions within a model, such as Mel09F, etc.

was shifted to the Me.109F series.1/

For the period of March-October 1941, the OSS production estimate increases more rapidly than the Air Ministry's. This view rests on two lines of reasoning:

1) In the spring of 1941, the Me.109F had reached full production. At this time, production of the F.W. 190 was initiated in the Focke-Wulf plant in Bremen which heretofore had been making the twin-engined Me.110. Thus it is reasonable to assume that the overall output of single-engined fighters increased. Subsequent to the autumn of 1941, however, factories devoted to the manufacture of the Me.109 were converted to the F.W. 190. If the total output of single-engine fighter planes rose at all, the rate of increase must have been much slower than it had been previously.

2) After the heavy losses suffered in the Battle of Britain, Germany had every incentive to expedite the production of fighters. This was further buttressed by the potential demands of the forthcoming Russian campaign.

Subsequent to October 1941, the OSS production estimate assumes that the output of single-engine fighters remained at a relatively constant level at which the rising output of the F.W. 190 was offset by the decline in production of the Me.109. But it may be observed that this assumption contains within it the implication that the growth in the output of the F.W. 190 was much slower than that estimated by the Air Ministry. (These differences have been set forth in Table I). The facts from which this last conclusion has been derived follow:

1. The F.W. 190 was reported to have been in production "in certain numbers" in August 1941. (AMWIS #103)

2. The plane was not seen on the Western Front until mid-October 1941. (AMWIS #113)

3. The Air Ministry estimate of an average monthly production of 65 during the period of July-December 1941 is unusually high for a plane only then appearing in combat.

4. The September 1, 1942, Air Ministry estimate indicates that the Focke-Wulf plant in Bremen and the Arado works in Warnemuende were the main production sources of the F.W. 190, with the one minor exception of the Fieseler factory in Kassel which at this time was just

---

1/ The first Me.109F was reported as having been sighted in February, 1940. This version of the Me.109 is believed to have reached a high level of production by the turn of the year since Moelder's squadron was equipped with it in March 1941. (Cf. AMWIS, various issues).

changing over from the Me.109. Yet the aerial photographic intelligence of the MEW reported that the Arado plant had been turning out the Me.109 in October 1941, which implies that these works shifted to the F.W. 190 at a date later than October 1941. In the light of this, then, an increase between October 1941, and August 1942, of 65 to 100 planes per month seems unduly slight.

In accordance with the above calculations, the OSS estimate, while accepting the Air Ministry figure of 100 planes per month production in August 1942, nevertheless shows a more gradual rise between the early part of 1941 and the 1942 terminal date than does the Air Ministry's estimate. However, it will be observed that the OSS estimate for September 1942, is considerably less than the Air Ministry's. The modification of the latter's figure has been prompted by the realization that the Air Ministry suggests a 40 percent increase in one month, (September over August) despite the fact that the increase during the whole first half of 1942 over the last six months of 1941 amounted to only 38 percent.

Since the present OSS estimate supposes that the F.W. 190's output increased more slowly in 1941, and more rapidly in 1942, (up to September) than the Air Ministry's estimate, it follows that the OSS estimate must assume that the production of the Me.109 fell more rapidly after the beginning of 1942. Against this, however, the Air Ministry shows an increased production of the Me.109 during 1942 at a time when plants were being converted to the F.W. 190.

2. Twin-Engine Fighters. Air Ministry and MEW estimates for the production of twin-engine fighters during the first year of the war are in substantial agreement. But beginning with September 1940, and clearly evident by January 1942, the MEW estimate rises faster and more consistently than that of the Air Ministry. This divergence in the two British estimates is attributable to the difference in measuring the output of the Me.110.

Chart II shows that the OSS estimate of twin-engine fighter production follows MEW's estimate up to November 1940, at which time both estimates are 30 planes per month higher than the Air Ministry's. The apparent reason for the latter's lower estimate lies mainly in the inconclusive opinions as to what, and how many aircraft were being turned out in the Messerschmidt's Regensburg plant. (In October 1941, for instance, the MEW estimated that the factory was turning out 60 Me.109's and 30 Me.110; but in August 1942, the Air Ministry asserted that the plant was producing only 45 Me.109's monthly. At this distance it is impossible to resolve the difference if, in fact, one exists.)

From the last quarter of 1940 on, the MEW curve shows an almost constant rate of acceleration. The Air Ministry and OSS estimates, on the other hand, do not reflect a similar trend since they take into account the conversion of the Focke-Wulf plant at Bremen from the Me.110 to the F.W. 190, and the later partial conversion of the Miag works in Brunswick from Ju.88's to Me.110's. This factor contributes to the

CHART I

SINGLE ENGINED FIGHTERS

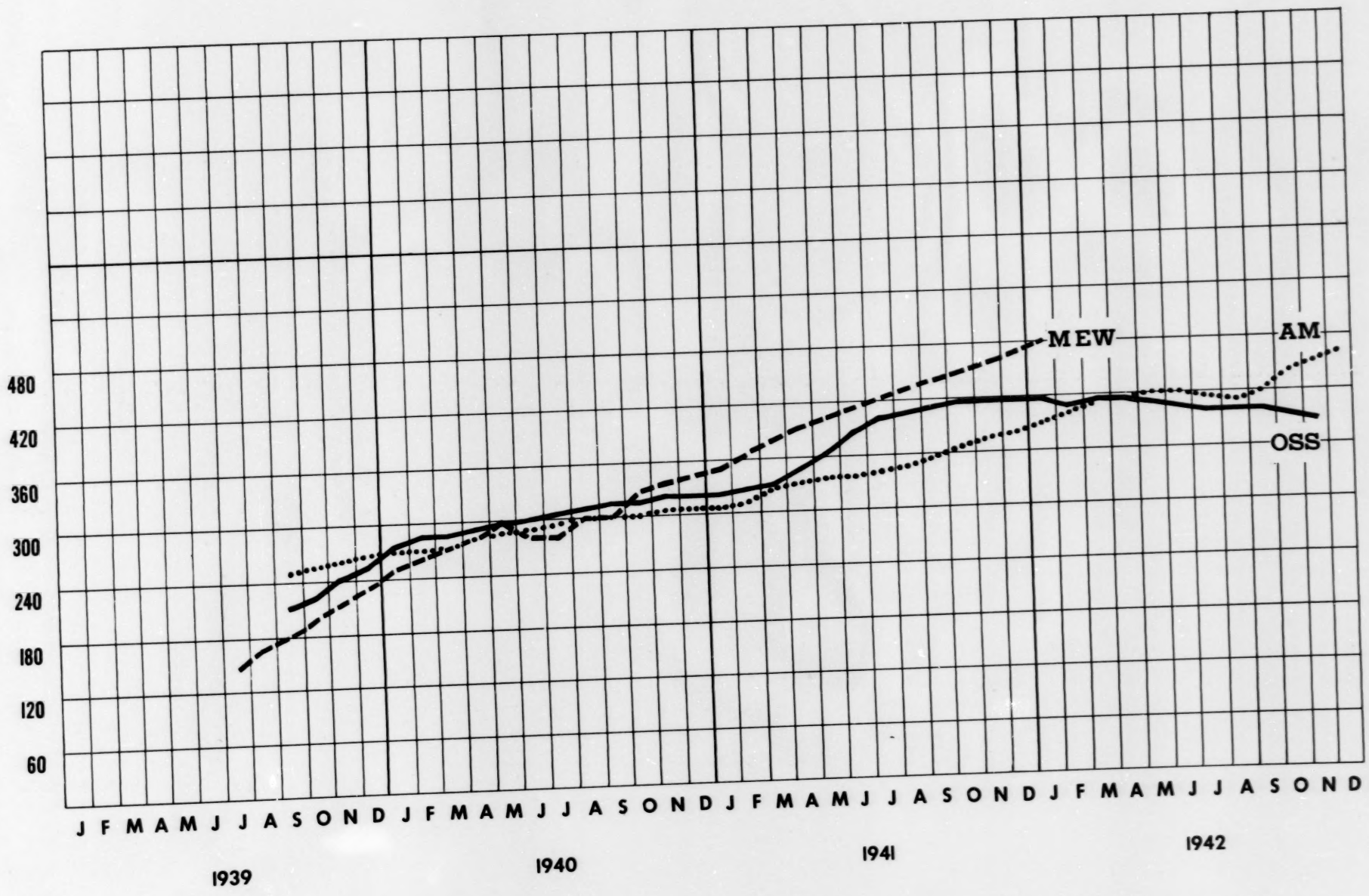
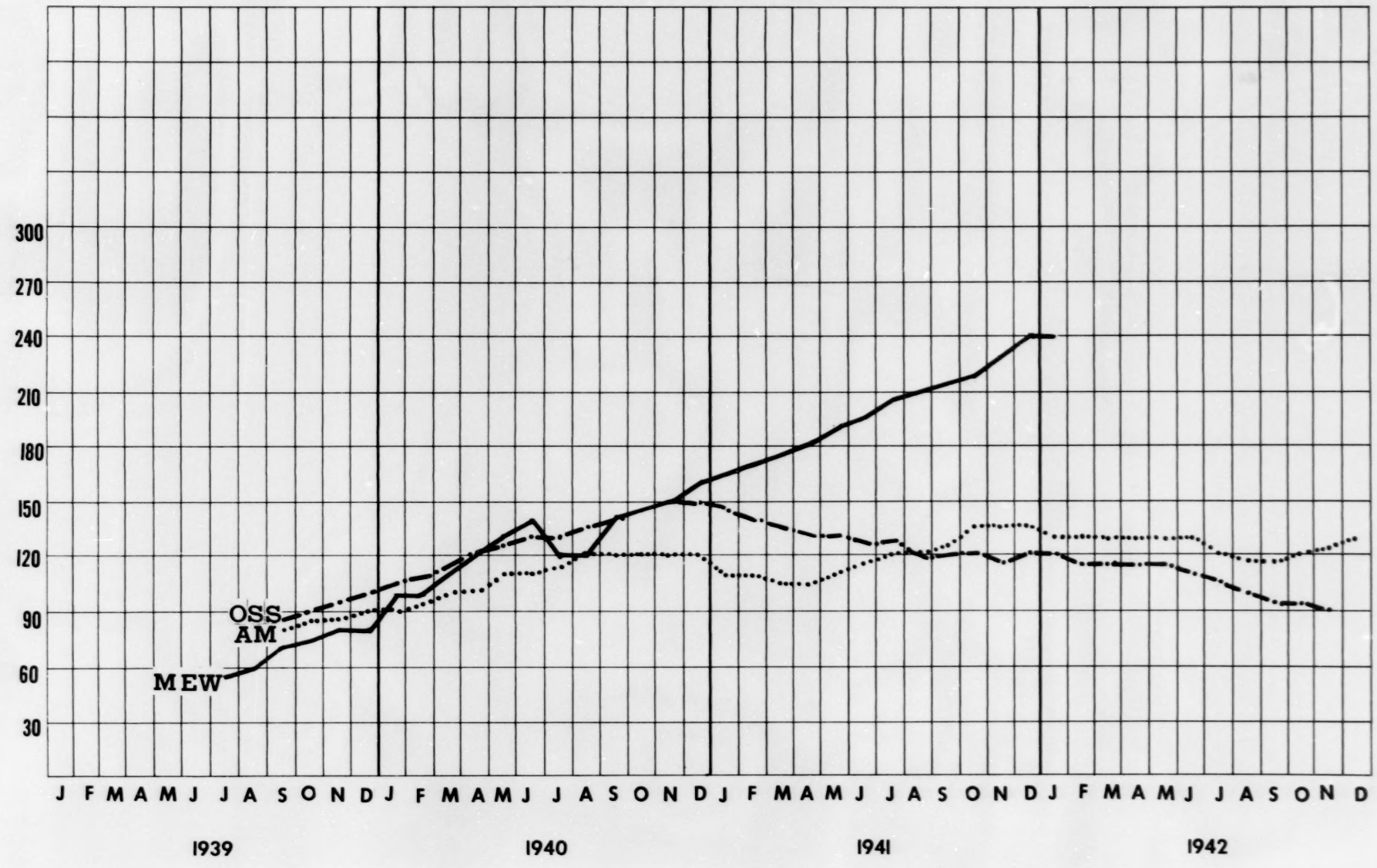


CHART 2

TWIN-ENGINED FIGHTERS



conditions represented in Chart II in which the estimates of the Air Ministry and those of the OSS approach each other closely in June 1941, and thereafter closely parallel each other until September 1942. At that date, the OSS figure is 20 planes per month below that of the Air Ministry. This difference is caused, in part, by the Air Ministry's inclusion of Ju.88's in the twin-engine fighter category, while in the OSS estimate these planes are placed in the class of long-range bombers. Table II summarizes the estimate of the output of twin-engine fighters. The separate series for the Me.210 is entirely speculative.

3. Dive Bombers. The most marked divergence between the Air Ministry and the MEW estimates by plane types may be found in their respective figures relating to the output of dive-bombers, and more specifically, in their estimates of the output of the Ju.87. (The twin-engine dive-bomber Henschel 129 has appeared only recently in production estimates. Other planes equipped with diving brakes, such as the He.111, the Do.217, and Ju.88, etc. are discussed in the "long-range bomber" section of this appendix.)

As shown in Chart III, the MEW curve exhibits a rapid rise in production of dive-bombers for the first year of the war, followed by a decline in the last quarter of 1940, and a more gradual rise in 1941. The Air Ministry estimate, however, suggests that production remained relatively constant after the outbreak of the war, that is, at approximately the same level as that indicated by the MEW. Then, after falling into a decline in the first half of 1941, production increases during the second half of 1941 to the round number of 100 per month which remains the production estimate for the remainder of the period under review.

The production curve developed by the OSS to conform to the overall estimate is, to all appearances, a crude compromise between these conflicting and extreme positions. Yet the supporting analysis for the OSS position has some basis, of both a subjective and objective character, the latter consisting of a study of aircraft plants.

On subjective grounds, the MEW decline in output seems premature, since it begins immediately after the unsuccessful dive-bomber phase of the Battle of Britain. A longer time-lag in the diminution of production appears to have been inevitable.

The OSS estimate acquires additional substance when the Air Ministry's contentions are subjected to an analysis of factory output:

German Production of the Ju.87

Plant	MEW Estimate for 10/41	AM Estimate for 10/42
Weser, Bremen	30)	
" , Lemwerder	30)	80
Bachmann, Furth	20	
Junkers, Bernburg	60	
" , Dessau	50	—
Total	190	80

(8800)

It will be noted that the Air Ministry reference makes no reference to the Bachmann plant at Furth. Excluding this, and the two Junker works, and making due allowance for the difference in their dates, the two estimates are in fair agreement.

What actually occurred at the Junkers plants is difficult to determine. Both the MEW and the Air Ministry believe that these factories turn out the Ju.88, as the following tabulation indicates:

Plant	MEW Estimate for 9/41	AM Estimate for 9/42
Junkers, Bernburg	60	
" , Dessau	40	115 1/
Total	100	115

The MEW estimates are based in large part on aerial photography and the recognition of planes parked on factory airports and aprons. Since it was this method that suggested strongly that Ju.87's were being produced at Bernburg and Dessau in 1941, and since the Air Ministry estimates reveal no production of that plane in 1942, a decline between 1941 and 1942 of some magnitude is indicated.2/

The OSS estimate starts with the assumption that this decline did take place, and is then extrapolated back to the beginning of the war when the three estimates are in approximate agreement. Table III summarizes the OSS data by models.

4. Long-Range Bombers. One of the widest discrepancies between the MEW and the Air Ministry estimates of German aircraft production occurs in long-range bombers. The difference centers on one particular model, the Ju.88. An analysis of its output by factories may serve to resolve some of the conflicting claims.

1/ Includes 40 equipped as twin-engine (night) fighters.

2/ It will be noted that the OSS estimate places the decline between February and September, 1941, that is, before the date of the MEW estimate. Two possible explanations are offered: The MEW estimate for September 1941, is taken to apply only figuratively to that exact month. In addition, the Ju.87's might have been still standing outside the factory, awaiting tests and final adjustments at the very time when the plant's assembly line was being converted entirely to the Ju.88.

(8800)

CHART 3

DIVE BOMBERS

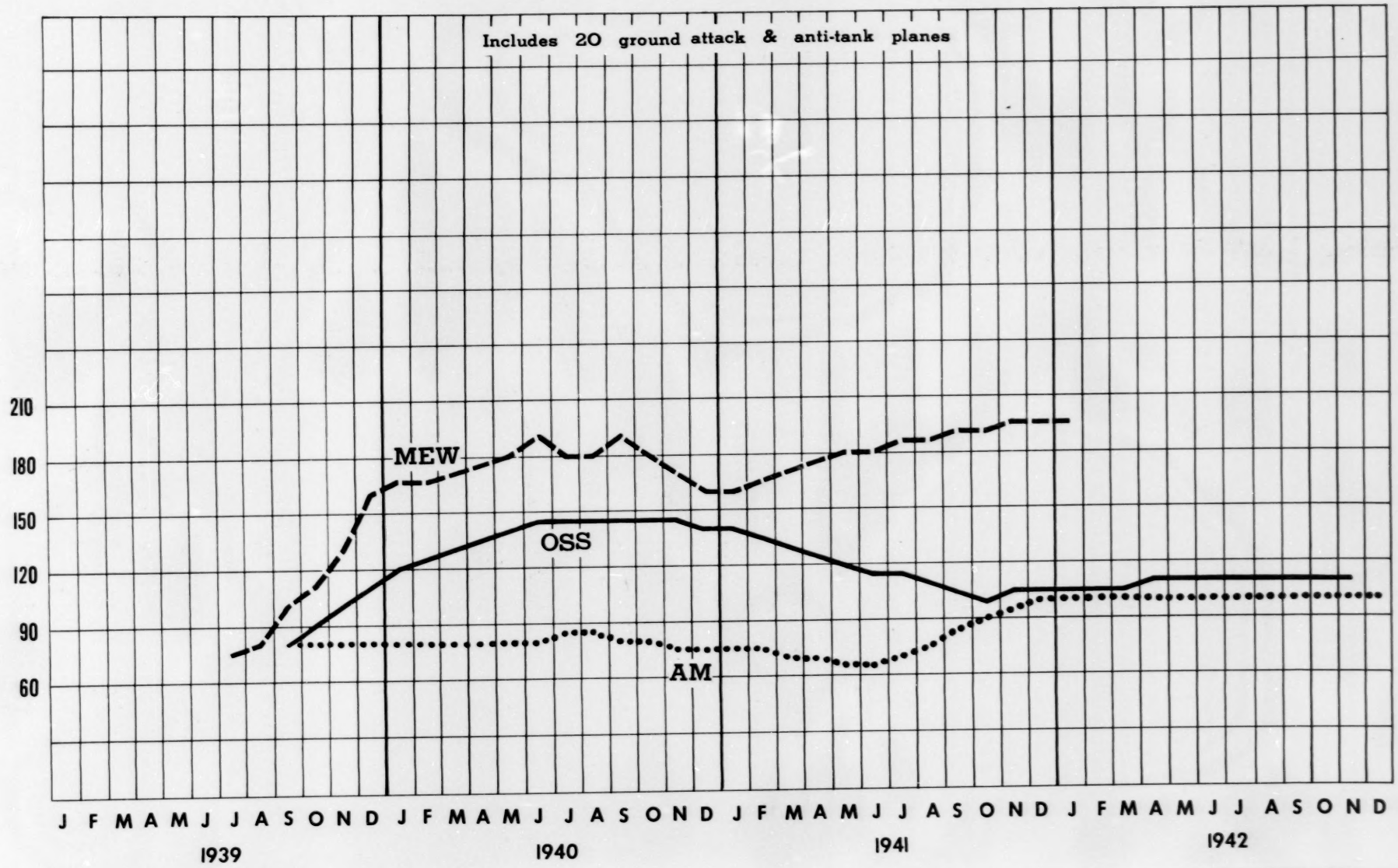
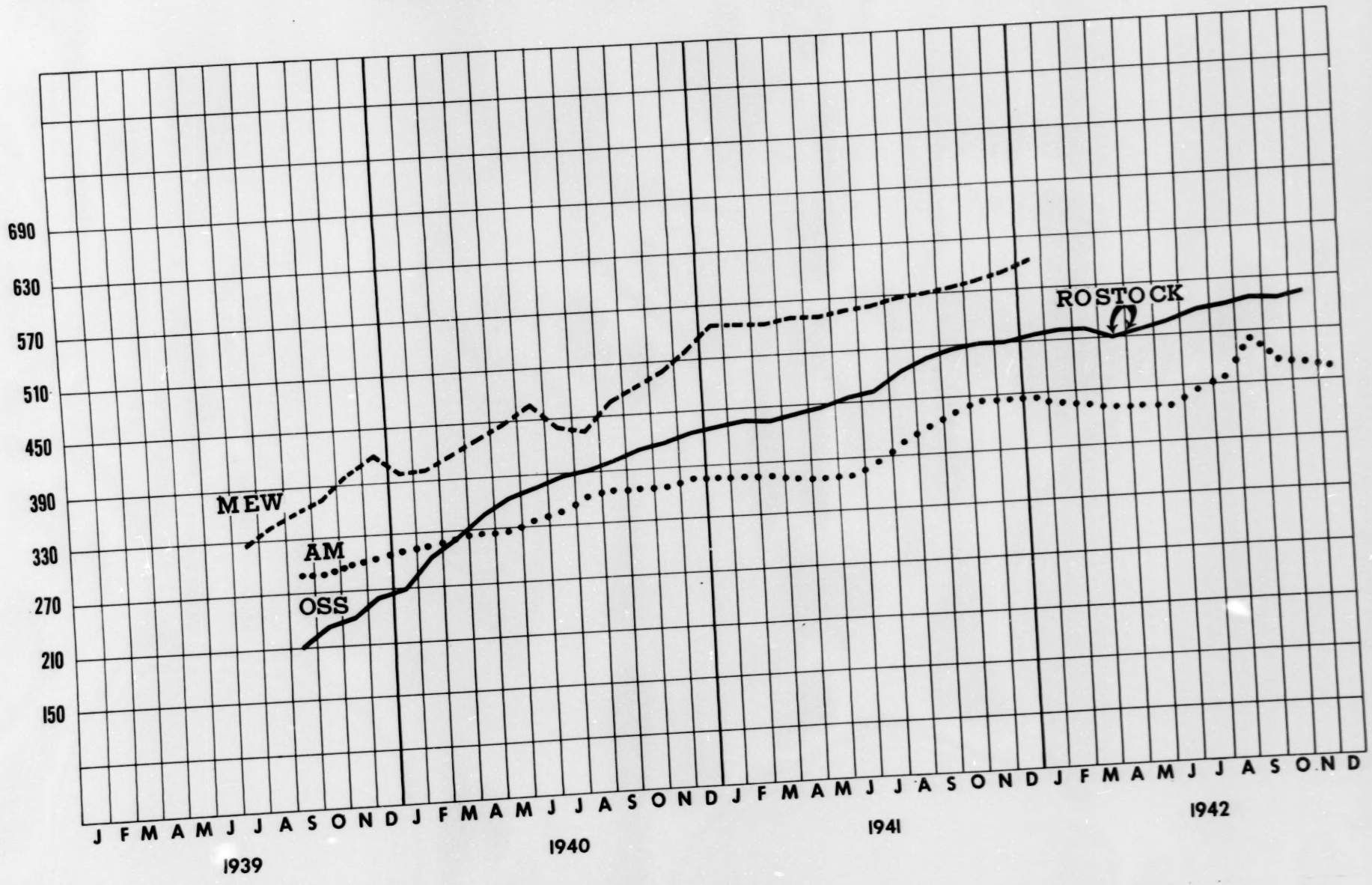

Includes 20 ground attack & anti-tank planes
210
180
150
120
90
60
MEW
OSS
AM
J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D
1939
1940
1941
1942

CHART 4

LONG RANGE BOMBERS



German Production Of The Ju.88

Plant	MEW Estimate for 9/41	AM Estimate for 9/42
ATC, Leipsig	30	30
Arado, Brandenburg-Neuendorf	25	30
Heinkel, Oranienburg	50	25
Henschel, Schonfeld	65	35*
Siebel, Halle	50	35
Junkers, Dessau	60)	
" , Bernburg	40)	115 2/
Dornier, Wismar	25	—*
Miag, Brunswick	10	—*
Misc. (incl. Arado, Rathenow)	—	45
Total	355 1/	315 2/

Some of the foregoing differences are easily accounted for by the difference in time periods. Of the plants marked with an asterisk (*), the Henschel works at Schonfeld are currently producing the Hs.129; the Dornier factory has been converted to the output of the Do.217; and the Miag plant presumably converted to the Me.110/210.

More difficult to resolve are the estimates of the output of the Junkers works at Dessau and at Bernburg. As already observed in the discussion of dive-bombers, the OSS estimate incorporates the view that these plants were turning out the Ju.87 in 1941, but that they abandoned that model for the Ju.88 towards the end of the same year. Assuming that, as a result of this conversion, some increase in the output of the Ju.88 followed, then the earlier MEW figure of 100 Ju.88's is too high in relation to the Air Ministry's 115 per month in September 1942.

It is assumed that the production lost through discontinuance of the output at the Henschel, Dornier, and Miag plants was more than balanced by increases in production at the Junker works, and possibly at the Rathenow factory. Production in September 1942, is estimated to have been 35 planes greater than in October 1941. This increment has been based upon the increased use of this plane as a night fighter.

Prior to October 1941, the OSS production curve for long range bombers reveals a more rapid rise than does either the Air Ministry or MEW curve. Since the Ju.88 was only beginning to come into first line combat units in appreciable strength early in 1940, (first

---

1/ Excluding the Blohm & Voss plant at Wenzendorf, originally listed at 25 planes per month, but later believed to be not working.

2/ Including 40 used as twin-engine (night) fighters.

line strength in March 1940 is estimated to have been 150 planes) it is believed that production of this plane at the outbreak of the war must have been relatively low. The OSS curve places the output at that time of the Ju.88 at a level which is 70 planes per month lower than the Air Ministry's estimate, and 150 planes lower than that of the MEW.

Little or no discrepancy exists in the estimates of production for the other long-range bombers, such as the He.111, the Do.17Z/217, the He.177, etc.

5. Army Co-operation and Observation. As shown in Chart V, there is little difference of opinion regarding the production of army co-op planes. The present estimate is closely parallel to that of the Air Ministry. Table 5 summarizes the position by models.

6. Coastal. In general, the present estimate for coastal aircraft parallels that of the Air Ministry, but at a level of some 30 planes more per month. The Air Ministry itself is relatively uncertain of the output of this craft, and it has been assumed that many of the planes listed by it as unidentified actually belong in this category. The Air Ministry estimate, for example, contains no mention of the He.115, which is usually considered a standard coastal model. The several overall estimates are given in Chart VI; the breakdown of the OSS estimate in Table 6.

CHART 5 & 6

ARMY CO-OP

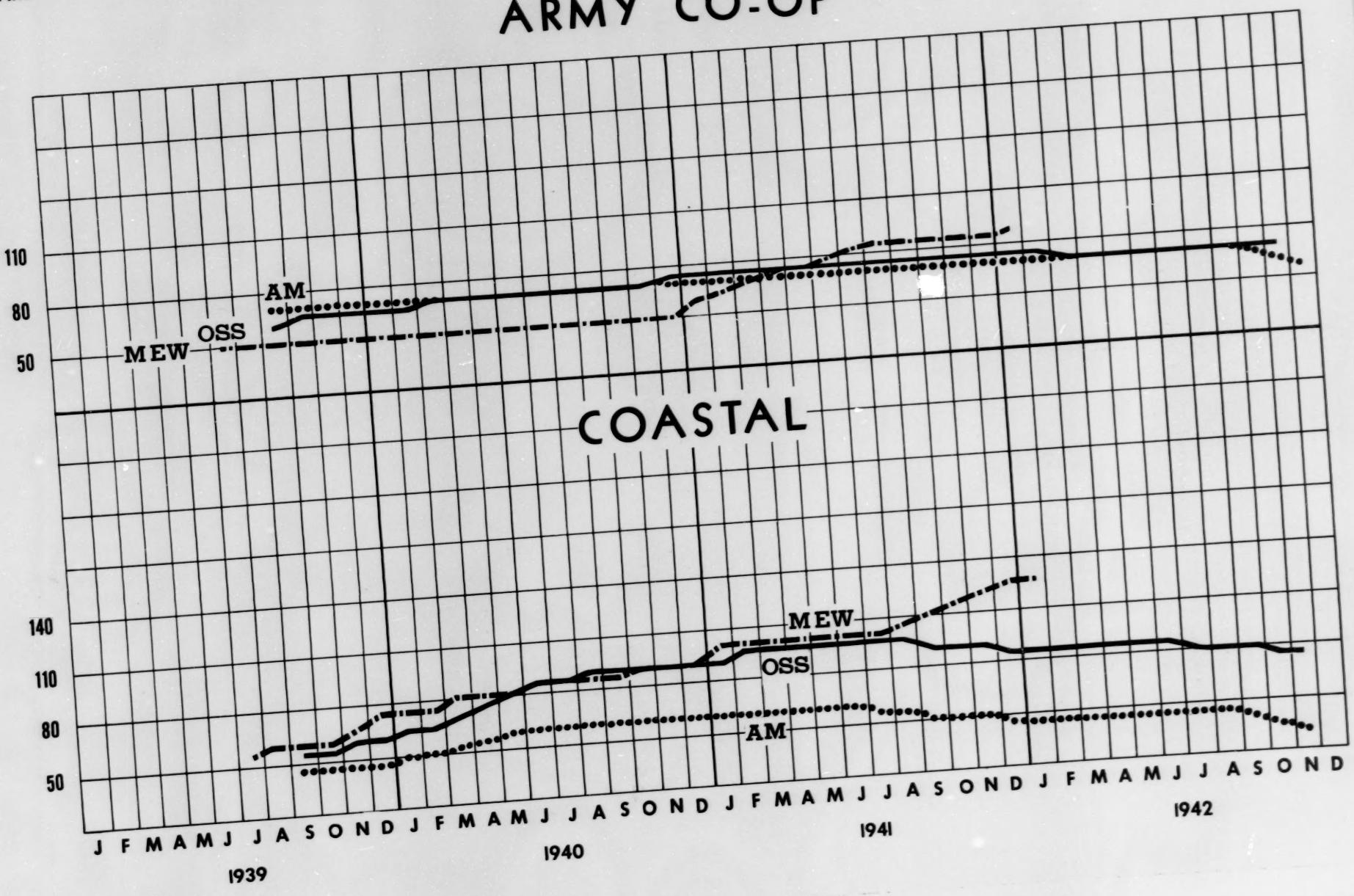


TABLE I

OSS Estimate of Production of Single-Engine Fighters

Date	Total	Me.109	F.W.190 OSS	F.W.190 AM
1939				
Sept.	210	210		
Oct.	220	220		
Nov.	240	240		
Dec.	255	255		
Total 1939	925	925		
1940				
Jan.	275	275		
Feb.	285	285		
Mar.	285	285		
Apr.	290	290		
May	295	295		
June	300	300		
July	305	305		
Aug.	310	310		
Sept.	315	315		
Oct.	315	315		
Nov.	320	320		
Dec.	320	320		
Total 1940	3615	3615		
1941				
Jan.	320	315	5)	
Feb.	325	320	5)	
Mar.	330	320	10)	20
Apr.	345	335	10)	
May	365	350	15)	
June	385	365	20)	
July	400	380	20)	
Aug.	405	385	20)	
Sept.	410	380	30)	65
Oct.	415	380	35)	
Nov.	415	370	45)	
Dec.	415	365	50)	
Total 1941	4530	4265	265	
1942				
Jan.	415	360	55)	
Feb.	410	340	70)	
Mar.	415	335	80)	90
Apr.	415	335	80)	
May	410	325	85)	
June	405	315	90)	
July	400	305	95	
Aug.	400	300	100	100
Sept.	400	290	110	140
Oct.	395	285	110	
Nov.	395	275	120	
Total 1942	4460	3465	995	415

(8800)

TABLE II

OSS Estimated Production of Twin-Engined Fighters

Date	Total	Me. 110	Me. 210
1939			
Sept.	85	85	
Oct.	90	90	
Nov.	95	95	
Dec.	100	100	
Total 1939	370	370	
1940			
Jan.	105	105	
Feb.	110	110	
Mar.	115	115	
April	120	120	
May	125	125	
June	130	130	
July	130	130	
Aug.	135	135	
Sept.	140	140	
Oct.	145	145	
Nov.	150	150	
Dec.	150	150	
Total 1940	1555	1555	
1941			
Jan.	145	145	
Feb.	140	140	
Mar.	135	135	
Apr.	130	130	
May	130	130	
June	125	125	
July	125	125	
Aug.	120	115	5
Sept.	120	110	10
Oct.	120	110	10
Nov.	120	100	20
Dec.	120	100	20
Total 1941	1530	1465	65
1942			
Jan.	120	100	20
Feb.	115	95	20
Mar.	115	95	20
Apr.	115	95	20
May	115	95	20
June	110	90	20
July	105	85	20
Aug.	100	80	20
Sept.	95	75	20
Oct.	95	75	20
Nov.	90	70	20
Total 1942	1175	955	220

(8800)

TABLE III

OSS Estimate of Production of Dive-Bombers

Date	Total	Ju.87	Hs.129
1939			
Sept.	80	80	
Oct.	90	90	
Nov.	100	100	
Dec.	110	110	
Total 1939	380	380	
1940			
Jan.	120	120	
Feb.	125	125	
Mar.	130	130	
Apr.	135	135	
May	140	140	
June	145	145	
July	145	145	
Aug.	145	145	
Sept.	145	145	
Oct.	145	145	
Nov.	145	145	
Dec.	140	140	
Total 1940	1660	1660	
1941			
Jan.	140	140	
Feb.	135	135	
Mar.	130	130	
Apr.	125	125	
May	120	120	
June	115	115	
July	115	110	5
Aug.	110	100	10
Sept.	105	90	15
Oct.	100	85	15
Nov.	100	85	15
Dec.	105	85	20
Total 1941	1400	1320	80
1942			
Jan.	105	85	20
Feb.	105	85	20
Mar.	105	85	20
Apr.	110	90	20
May	110	90	20
June	110	90	20
July	110	90	20
Aug.	110	90	20
Sept.	110	90	20
Oct.	110	90	20
Nov.	110	90	20
Total 1942	1195	975	220

(8800)

TABLE IV

OSS Estimate of Production of Long-range Bombers 1/

Date	Total	Ju.88	He.111	Do-215/17Z	Do.217	He.177	F.W.200
1939							
Sept.	210	100	60	45			5
Oct.	230	120	60	45			5
Nov.	240	125	65	45			5
Dec.	260	145	65	45			5
Total	940	490	250	180			20
1940							
Jan.	270	145	70	50			5
Feb.	300	175	70	50			5
Mar.	310	185	70	50			5
Apr.	340	215	70	50			5
May	360	230	75	50			5
June	370	240	75	50			5
July	385	255	75	50			5
Aug.	390	260	75	50			5
Sept.	400	265	80	50			5
Oct.	410	275	80	50			5
Nov.	420	280	80	55			5
Dec.	425	285	80	55			5
Total	4380	2810	900	610			60
1941							
Jan.	430	285	85	55			5
Feb.	435	290	85	55			5
Mar.	435	290	85	45	10		5
Apr.	440	295	85	35	20		5
May	445	295	90	25	30		5
June	455	300	95	20	35		5
July	460	310	95	10	40		5
Aug.	480	315	95	10	55		5
Sept.	495	320	95	5	65	5	5
Oct.	505	330	95	5	65	5	5
Nov.	510	335	95		70	5	5
Dec.	510	335	95		70	5	5
Total	5600	3700	1095	265	460	20	60
1942							
Jan.	515	340	95		70	5	5
Feb.	520	340	95		70	10	5
Mar.	520	340	95		70	10	5
Apr.	510	340	90		70	5	5
May	515	345	90		70	5	5
June	525	345	95		70	10	5
July	535	350	95		75	10	5
Aug.	540	355	95		75	10	5
Sept.	545	355	95		75	15	5
Oct.	545	355	95		75	15	5
Nov.	550	360	95		75	15	5
Total	5820	3825	1035		795	110	55

1/ Including those used for Reconnaissance (except the Ju-86-P) and for T.E. (night) fighting.

TABLE V

OSS Estimate of Production of Army Coop/Reconnaissance Planes

Date	Total	Hs-126	Hs(Bv-141	FW-189	Ju.86-P
1939					
Sept.	60	50		10	
Oct.	65	55		10	
Nov.	65	55		10	
Dec.	65	55		10	
Total 1939	255	215		40	
1940					
Jan.	65	55		10	
Feb.	65	55		10	
Mar.	70	55		15	
Apr.	70	55		15	
May	70	55		15	
June	70	55		15	
July	70	55		15	
Aug.	70	55		15	
Sept.	70	55		15	
Oct.	70	55		15	
Nov.	70	55		15	
Dec.	75	55		20	
Total 1940	835	660		175	
1941					
Jan.	75	55		20	
Feb.	75	55		20	
Mar.	75	55		20	
Apr.	75	55		20	
May	75	55		20	
June	75	55		20	
July	75	55		20	
Aug.	75	55		20	
Sept.	75	55		20	
Oct.	75	55		20	
Nov.	75	55		20	
Dec.	75	55		20	
Total 1941	900	660		240	
1942					
Jan.	75	45	10	15	5
Feb.	75	45	10	15	5
Mar.	70	40	10	15	5
Apr.	70	40	10	15	5
May	70	40	10	15	5
June	70	40	10	15	5
July	70	40	10	15	5
Aug.	70	40	10	15	5
Sept.	70	40	10	15	5
Oct.	70	40	10	15	5
Nov.	70	40	10	15	5
Total 1942	780	450	110	165	55

TABLE VI

OSS Estimate of Production of Coastal Aircraft

Date	Total	He.115	Ar.196	Bv.138	Do.24	Ar.95	Do.18
1939							
Sept.	55	15	15	10	5	5	5
Oct.	55	15	15	10	5	5	5
Nov.	60	15	15	10	5	5	10
Dec.	60	15	15	10	5	5	10
Total 1939	230	60	60	40	20	20	30
1940							
Jan.	65	20	15	10	5	5	10
Feb.	65	20	15	10	5	5	10
Mar.	70	20	20	10	5	5	10
Apr.	75	20	20	10	10	5	10
May	80	20	20	10	10	5	15
June	85	20	20	10	10	10	15
July	85	20	20	10	10	10	15
Aug.	90	20	20	15	10	10	15
Sept.	90	20	20	15	10	10	15
Oct.	90	20	20	15	10	10	15
Nov.	90	20	20	15	10	10	15
Dec.	90	20	20	15	10	10	15
Total 1940	975	240	230	145	105	95	160
1941							
Jan.	90	20	20	15	10	10	15
Feb.	95	20	20	20	10	10	15
Mar.	95	20	20	20	10	10	15
Apr.	95	20	20	20	10	10	15
May	95	20	20	20	10	10	15
June	95	20	20	20	10	10	15
July	95	20	20	20	10	10	15
Aug.	95	20	20	20	10	10	15
Sept.	90	15	20	20	10	10	15
Oct.	90	15	20	20	10	10	15
Nov.	90	15	20	20	10	10	15
Dec.	85	15	15	20	10	10	15
Total 1941	1110	220	235	235	120	120	180
1942							
Jan.	85	15	15	20	10	10	15
Feb.	85	15	15	20	10	10	15
Mar.	85	15	15	20	10	10	15
Apr.	85	15	15	20	10	10	15
May	85	15	15	20	10	10	15
June	85	15	15	20	10	10	15
July	80	15	15	20	10	10	10
Aug.	75	15	15	20	10	5	10
Sept.	75	15	15	20	10	5	10
Oct.	75	15	15	20	10	5	10
Nov.	75	15	15	20	10	5	10
Total 1942	890	165	165	220	110	90	140

APPENDIX II. GERMAN PRODUCTION OF AIRPLANE ENGINES AND THE PROBLEM OF OBSOLESCENCE

A. Increase in Horsepower

On the basis of the estimates of German aircraft output by models, developed in Appendix I, an attempt has been made to estimate the output of aircraft engines by models. The aircraft estimate rests shakily upon a towering structure of assumptions; a fortiori does that of engines, since additional hypotheses have been introduced at three separate points:

1. It has been assumed that two engines are required for each engine mount in a combat plane. If requirements for spare engines and spare sub-assemblies and small parts are roughly similar for engines of all horsepowers regardless of the type of plane in which the original engine is mounted, this assumption is satisfactory enough. Whether or not 2, 2.5 or 3 engines per engine mount are required is a factor that will change the number of engines needed but not the relative numbers for engine models required. Interest in the present study attaches more to the relative output of engines of various horsepower than to total numbers of engines. If, on the other hand, requirements for spares and spare parts differ from engine to engine, depending on their type, the underlying basis of the study is destroyed. It is doubted that these requirements will so differ.1/

2. Where a given model is powered with different engines in different versions, an arbitrary allocation of engine models has been made. In some cases, the allocation has not been entirely arbitrary, especially where there are indications that "most" of a model is equipped with one engine-model. (Errors made under this assumption may, in some cases, cancel out.) Specifically, the following assumptions have been made:

   a. That the output of the Do.17-Z, mounting a Bramo Fafner engine, and the Do.215, using the DB601-A engine, were equal;

   b. That after January 1, 1941, the output of the F.W.200-Kurier (B.M.W.801's) and F.W.200-Kondor (B.M.W.132's) were equal;

   c. That the output of the Ju.89 (Jumo 211's) and of the Ju.90 (B.M.W.132-H) were equal;

1/ General American experience at present indicates that the usage to which a motor is put -- transport, bomber -- is more important in determining the spare part requirements than whether it be radial or an in-line engine.

d. That after January 1, 1942, 10 percent of the Ju. 88's produced were equipped with B.M.W. 801's, while the remainder continued to be powered with the Ju.211;

e. That 90 per cent of the Ju.52's were powered with the B.M.W.132, the remainder with the D.B.601.

3. Finally, it has been assumed that a three months time-lag intervenes between the production of an engine and the finished plane into which it is assembled.

Table XI on the following page summarizes the estimates of engine output, derived on the foregoing assumptions. The annual results are plotted on Charts 7 to 10. As shown on these charts, the average horsepower of German engines has risen as follows:

Year	Average Horsepower of German Engines
1939	1,050
1940	1,100
1941	1,150
1942	1,210

This relatively constant rise in average horsepower since 1939 is due to the introduction of the B.M.W.801, rated at 1580-1600 hp.1/ and to the scaled-up versions of the DB 601, the "E" (1,400 hp.) and the "N" (1,250 hp.), both of which were in production at the end of 1940. This gain, however, is overstated in the foregoing averages, since the B.M.W. 801 has been "derated" to below 1,500 hp. in the F.W.190, and possibly in other planes.

B. The Timing of Model Changes

An examination of changes in German airplanes and hence in engines indicates not only that such changes have occurred infrequently, but that most of the shifts took place in the winter of 1940-1941.

There were only minor conversions and substitutions in the first year of the war, namely, the elimination of certain obsolescent models, such as the He.51 single-engine fighter which was discarded from combat squadrons as the mass production of models introduced in 1938 became effective.2/

1/ Horsepowers given are maximum (emergency) output.

2/ The He.111-K Mark V may have been replaced by the Mark Va in this period. This would not affect the foregoing contention, since the change from the D.B. 601-A to the Ju.211-A engine resulted in only a minor increment in horsepower.

TABLE XI

ESTIMATED PRODUCTION OF GERMAN COMBAT AND TRANSPORT AIRCRAFT MOTORS

(Assuming a production of two engines per engine mount)

	Daimler-Benz			B.M.W.		Junkers			Bramo-	Arado	Gnome Rhone	
Engine	601	605	606	132	801	205	207	211	Fafnir	AR-410	14m	Total
1939 1/	15,500	-	-	5780	-	1,130	-	9,890	1,510	510	-	34,320
1940	15,660	-	-	7,180	140	1,720	-	19,440	1,710	800	-	46,650
1941	15,030	80	180	7,080	4,260	2,160	60	22,430	660	1,460	-	53,400
1942 2/	11,670	1,020	510	6,540	8,040	2,010	240	22,110	360	720	960	54,180
Total	57,860	1,100	690	26,580	12,440	7,020	300	73,870	4,240	3,490	960	188,550

1/ Annual production based on estimated output for the last seven months.

2/ Annual production based on estimated output for first half year.

SECRET

The winter of 1940-1941, as stated above, witnessed the greatest number of significant changes. Among the fighters, the Me.109-E, powered by the D.B.601-A (1,175 hp.) was converted to the 109-F, equipped with the stepped-up "N" or "E" versions of the same engine. The B.M.W. 801 engine was placed into production and used to power the new F.W.190. Among bombers, the Do.17Z/215 (the former with Bramo Fafner, the latter with D.B. 601-A engines) were abandoned for the Do.217 which is powered by the B.M.W.801. Facilities for the He.177 also were constructed in the first half of 1941, enabling the plane to go into production in the latter portion of the year. It is powered by the D.B.606 engine which is actually two D.B.601's coupled together to a single propeller.

The higher horsepower engines also appeared in standard aircraft. Many of the Me.110's examined by the British were found to have been equipped with the D.B.601-N, while the B.M.W.801 is known to have been used in the F.W.200. Somewhat later than the winter of 1941, the B.M.W.801 was introduced into some Ju.88's.

Since the summer of 1941 four new aircraft have been brought into production. These are the above mentioned He.177, the Hs.129, the Me.210 and the Me.109G. It is especially significant that, although this is a greater number of new aircraft than was introduced in the winter of 1940-1941, the volume of their output at present remains unimportant. After being in production well over a year, the production of the He.177 is at present estimated at 15 planes per month; the Hs.129, in production a comparable time, is at present being turned out at the rate of 20 per month, while the Me.210, believed in production since September 1941, is probably not being produced in any larger quantities than the Hs.129, and production of this aircraft may have been curtailed altogether. Finally, the Me.109G, ostensibly a series change, has not been observed in substantial quantities to date. Indeed, the future of this model is itself in some doubt for the present trend is apparently one of replacement by the **F.W.190.** Study of the engines of these new planes is especially interesting; with the exception of the Me.109G, which is believed to be powered by the DB-605 (maximum of 1700-1800 hp.) none of these new planes have "new" engines. The He.177 is powered by 2 DB-606's -- essentially the equivalent of 4 DB-601's; the original version of the Hs.129 was equipped with the old, lowpowered Argus-As-410 (450-500 hp.); the newer version has Grench Gnome-Rhome 14M (850 hp.) engine. The Me.210 has DB-601-F in its present form. In other words, most of these "new" aircraft have engines that have been in production since the winter of 1941.

Germany is, of course, currently engaged in developing newer, more powerful engines -- the DB-603 and 605 (mentioned above), developing about 1800 hp., the 18 cylinder radial B.M.W.-802, developing a maximum of 2,200 hp., the Jumo-222, of comparable power, to name a few. These are still in experimental development or at best in small scale production and are confined to planes still "under wraps."

1939

CHART 7

OUTPUT of GERMAN AIRPLANE ENGINES

(Estimated for tactical planes by horsepower - Last 7 months on a yearly basis)

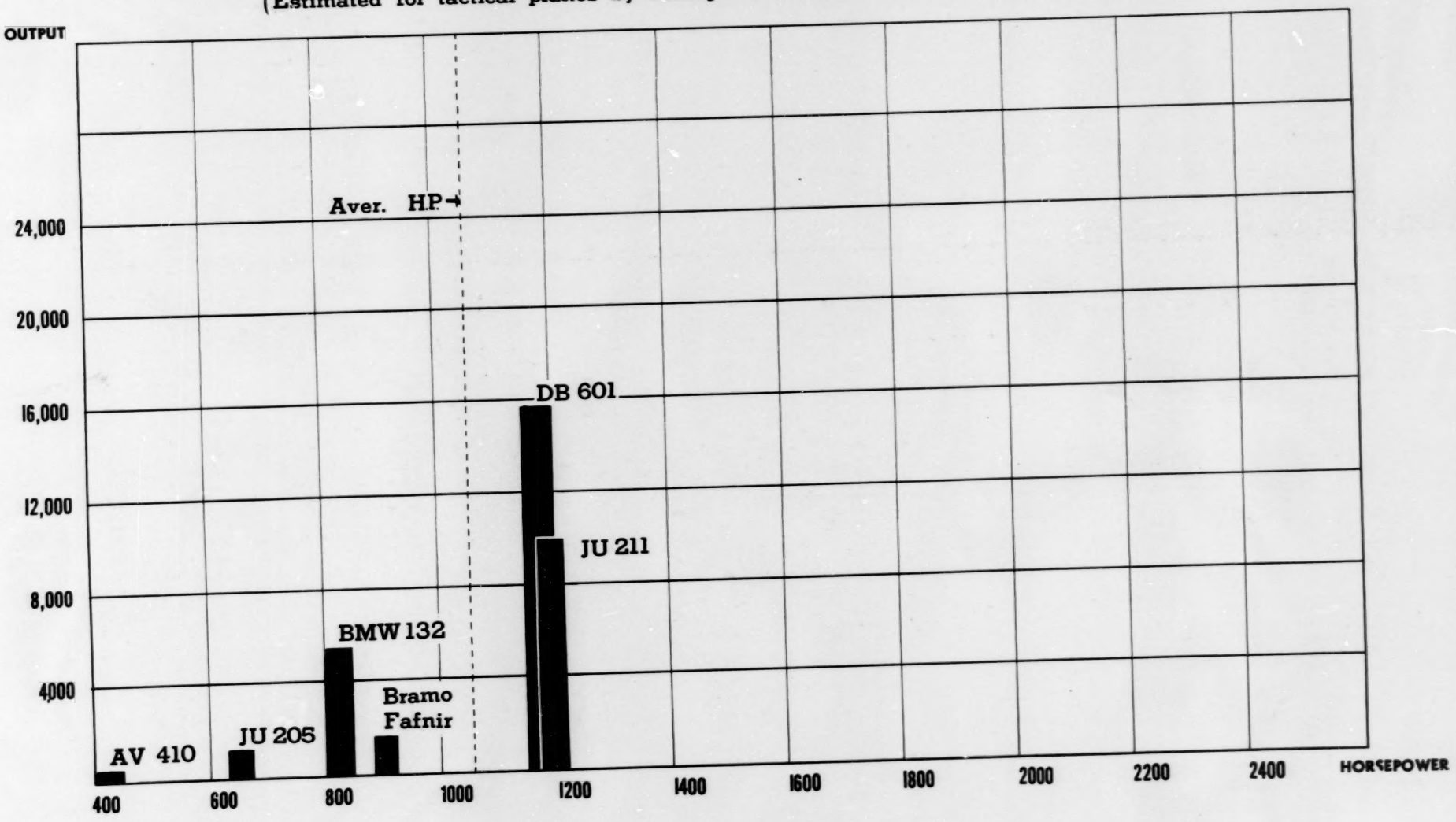


CHART 8

1940

OUTPUT of GERMAN AIRPLANE ENGINES

Estimated for tactical planes by horsepower

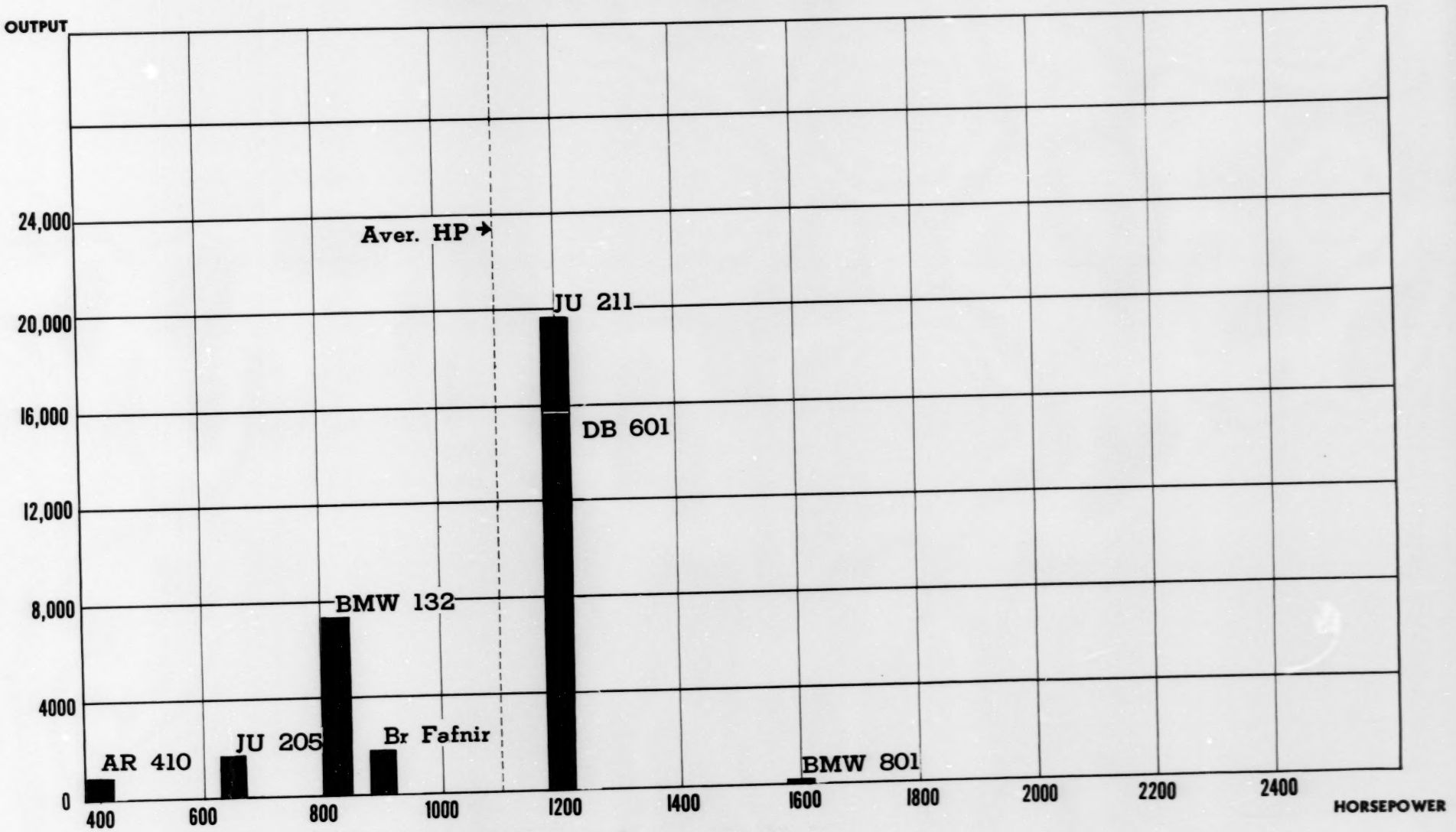


CHART 9

1941

OUTPUT of GERMAN AIRPLANE ENGINES

(Estimated for tactical planes) by horsepower

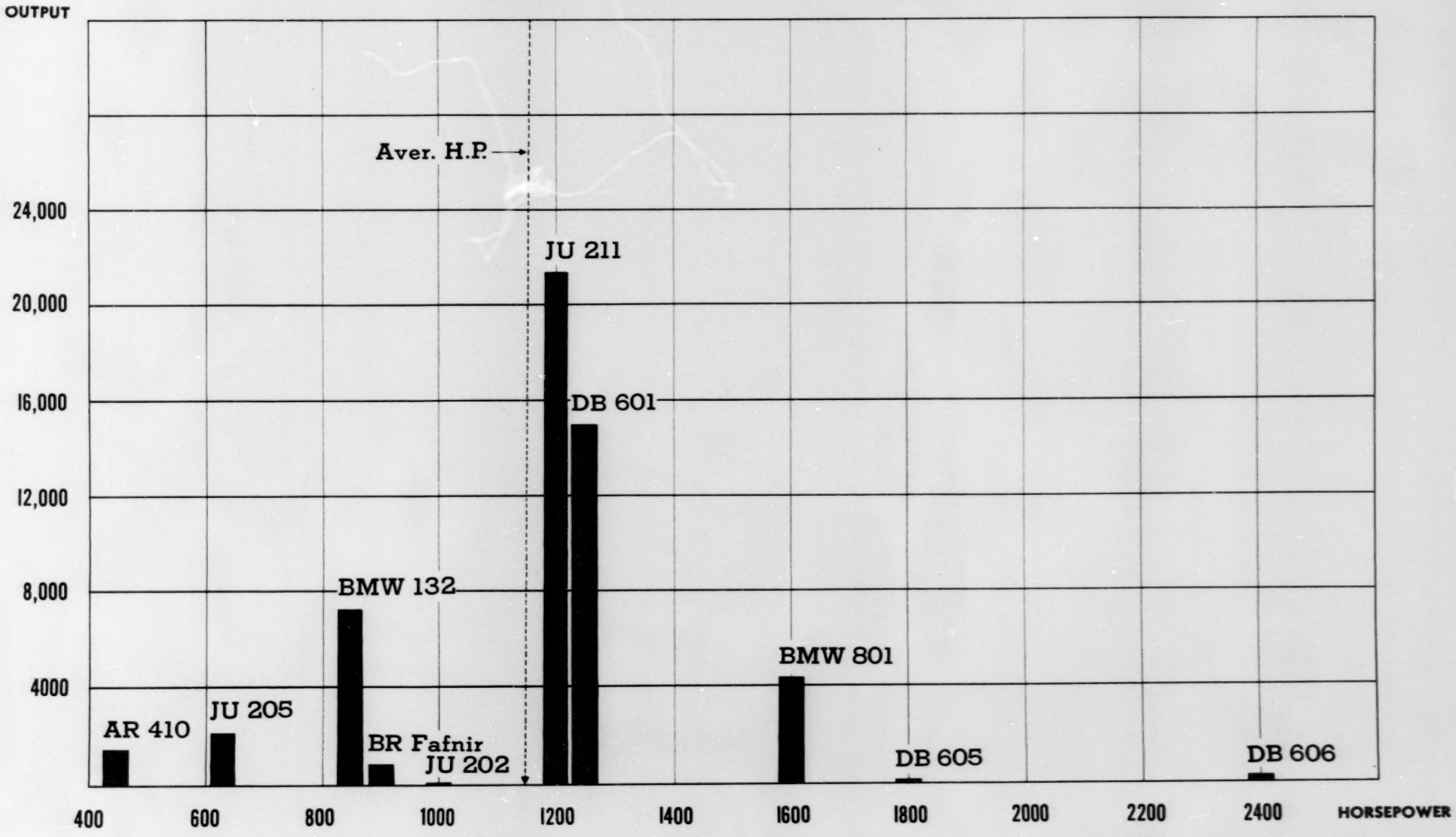
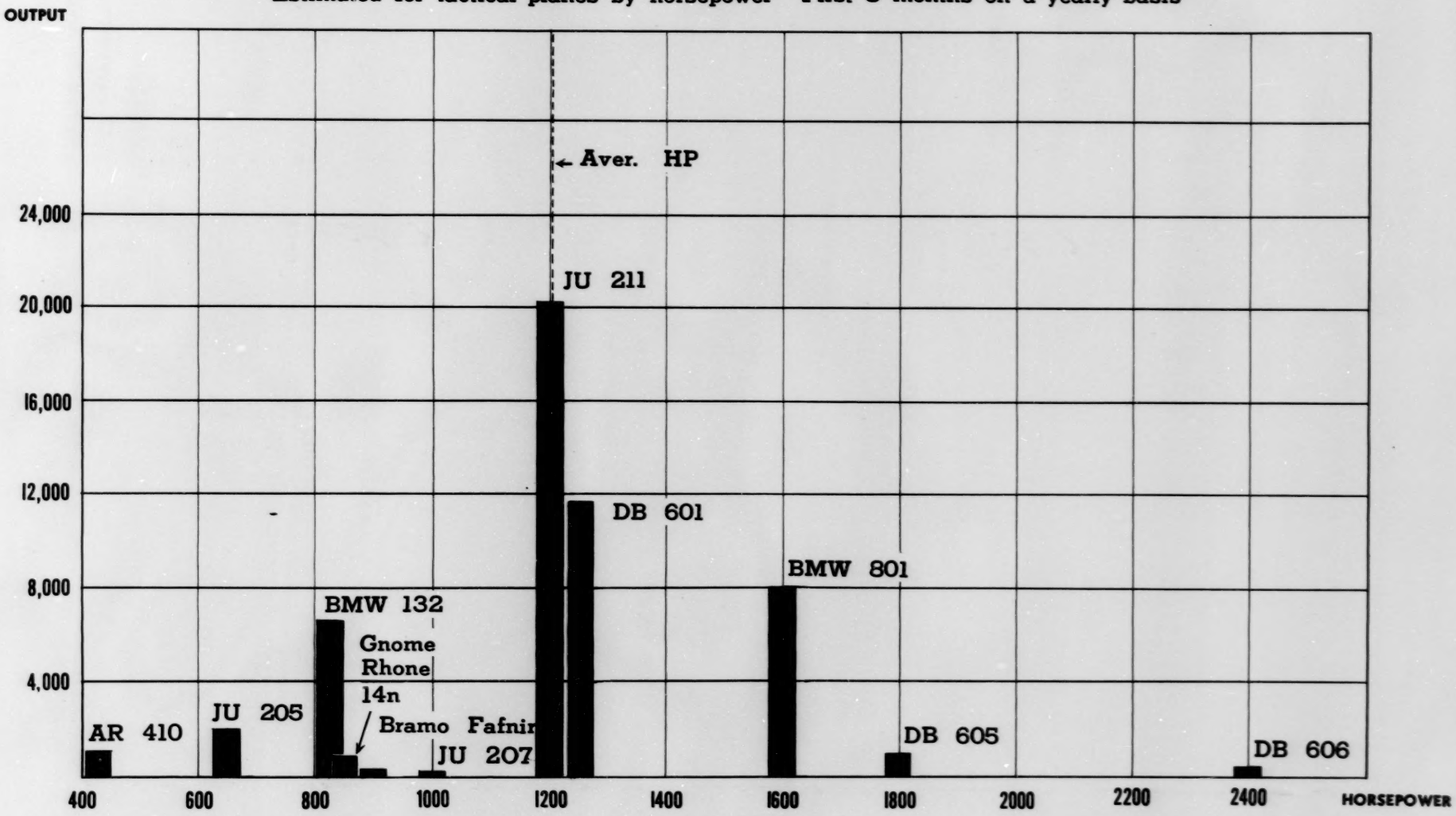


CHART 10

1942

OUTPUT of GERMAN AIRPLANE ENGINES

Estimated for tactical planes by horsepower First 8 months on a yearly basis



The fact that Germany's major change-over occurred in the winter of 1940-41 is significant. The GAF had suffered serious losses in the Battle of Britain, but when the decision to invade the British Isles was revoked, German aircraft production was more than ample. If new models had not been introduced into production, German first-line strength and reserves of aircraft could have been increased far above the 10,000 level reached in the late spring of 1941. The production loss occasioned by the changeover in models, came when Germany strategically could afford to accept it.

Quantitatively, the GAF is now far below its peak strength. Its ability to rebuild strength is seriously open to question because of the loss of the usual winter lull in aerial warfare.

Germany is faced with the need to develop newer and more powerful airplanes capable of superior performance at all altitudes. For the coming year we will see the GAF confronted with increasing numbers of fighter planes specialized to excel within definite altitude ranges. These planes will have the tactical advantage of largely being able to choose or refuse battle -- to their own liking. To meet this prospect, the performance of the FW. 190 and the production of the Me109G will have to be stepped up. Moreover, reports indicate that the BMW-801 still is plagued with "bugs" which limit the use of its maximum power; that the output of the DB-605 is just out of experimental stage; and that the Me109G itself may still have some structural weaknesses.

Although Germany has undoubtedly undertaken a vast amount of the experimental work necessary for her to bring forth more modern planes equipped with more powerful engines, in the present state of the German labor supply, it is doubtful whether these can be put into production outside of the existing airplane factories or except at the cost of drawing labor from these factories. Whether Germany will be able to forego the production of existing models in order to retool to turn out more powerful planes, is seriously open to question.

C. Summary

The present production of engines is largely absorbed by relatively basic types of airplanes.

1. Junkers 205 is being used to power standard coastal types, the 207 the high-altitude Ju-86-P; the 211, the He.111-19MKVa, the Ju.87, 88, and 89. Production by this firm has remained relatively constant for the past year and one-half, and any major new development seems unlikely. (See Table 9)

2. B.M.W. is at present still expanding. Its output of the older 123 engine has remained constant throughout the war, it being the principal power plant for many coastal, observation, and transport types. (The He. 115, Do-24, Av-95, Hs.126, F.W. 200, Ju-52, Ju-90) Production of the newer 801 has expanded continuously since the first of 1941 but there are signs that the output of this engine is now levelling off. As

mentioned above its present "derated" use strongly suggests that the experimental 802 will not be brought into large-scale production during the coming year. (See Table 8)

3. Production of Daimler-Benz-601 has declined somewhat during the past year, being principally confined to two planes -- the Me.109F and 110 at present. In past years the He.111-19 MKY, Do-215 were also powered by this engine. Should the new Me.109-G come into greater prominence it seems probable that plant facilities at Daimler-Benz could easily switch to the more powerful DB-605. However, the entire fate of the Me.109 series seems in doubt at present; the present trend suggests this model is being shifted to F.W.190's. (See Table 7)

4. Production of Bramo and Argus engines is slight and confined to basic coastal and reconnaissance types. (See Table 10)

5. It thus seems unlikely that, unless there is considerable expansion in the aircraft industry, there will be significant changes in the hp. of German aircraft engines during the coming year. The DB-605 is the most probable "new" engine to be put into anything like large-scale production.

TABLE VII

Estimated Output of Daimler Benz Aircraft Motors

Date	Production per engine frame										Est. Total production (twice est. prod./Engine frame)
		D B - 601				D B - 605		DB-606		Total	
	He.111K MK V	Me-109 E & F	Me.110	Do. 215	Ju. 52	Me. 210	Total	Me. 109-G	He. 177		
1939											
June	120	210	170	45	15	-	560	-	-	560	1,120
July	120	220	180	45	15	-	580	-	-	580	1,160
Aug.	130	240	190	45	15	-	620	-	-	620	1,240
Sept.	130	255	200	45	15	-	645	-	-	645	1,290
Oct.	140	275	210	50	15	-	690	-	-	690	1,370
Nov.	140	285	220	50	15	-	710	-	-	710	1,420
Dec.	140	285	230	50	15	-	720	-	-	720	1,440
Tot.'39 (7 mo.)	920	1,770	1,400	330	105	-	4,525	-	-	4,525	9,050
1940											
Jan.	140	290	240	50	15	-	735	-	-	735	1,470
Feb.	150	295	250	50	15	-	760	-	-	760	1,520
Mar.	150	300	260	50	15	-	775	-	-	775	1,550
Apr.	-	305	260	50	15	-	630	-	-	630	1,260
May	-	310	270	50	15	-	645	-	-	645	1,290
June	-	315	280	50	15	-	660	-	-	660	1,320
July	-	315	290	50	15	-	670	-	-	670	1,340
Aug.	-	320	300	55	15	-	685	-	-	685	1,370
Sept.	-	320	300	55	15	-	690	-	-	690	1,380
Oct.	-	315	300	55	15	-	690	-	-	690	1,380
Nov.	-	320	280	55	15	-	670	-	-	670	1,340
Dec.	-	330	270	45	15	-	660	-	-	660	1,320
Tot.'40	440	3,735	3,300	615	180	-	8,270	-	-	8,270	16,540
1941											
Jan.	-	335	260	35	15	-	645	-	-	645	1,290
Feb.	-	350	260	25	15	-	650	-	-	650	1,300
Mar.	-	365	250	20	15	-	650	-	-	650	1,300
Apr.	-	380	250	10	15	-	655	-	-	655	1,310
May	-	385	230	10	15	10	650	-	-	650	1,300
June	-	380	220	5	15	20	640	-	10	650	1,300
July	-	380	220	5	15	20	640	-	10	650	1,300
Aug.	-	370	200	-	15	40	625	-	10	635	1,270
Sept.	-	365	200	-	15	40	620	-	10	630	1,260
Oct.	-	350	200	-	15	40	605	10	10	625	1,250
Nov.	-	330	190	-	15	40	575	10	20	605	1,210
Dec.	-	315	190	-	15	40	560	20	20	600	1,200
Tot.'41	-	4,305	2,670	110	180	250	7,515	40	90	7,645	15,290
1942											
Jan.	-	305	190	-	15	40	550	30	10	590	1,180
Feb.	-	295	190	-	15	40	540	30	10	580	1,160
Mar.	-	275	180	-	15	40	510	40	20	570	1,140
Apr.	-	265	170	-	15	40	490	40	20	550	1,100
May	-	250	160	-	15	40	465	50	20	535	1,070
June	-	240	150	-	15	40	445	50	30	525	1,050
July	-	245	150	-	15	40	450	50	30	530	1,060
Aug.	-	245	140	-	15	40	440	50	30	520	1,040
Tot.'42	-	2,120	1,330	-	120	320	3,890	340	170	4,400	8,800

(8800)

TABLE VIII

Estimated Output of Bayrische Motoren Werke - Aircraft Motors

Date	Production per Engine Frame														Est. Total Production (twice est. prod./engine frame)
	BMW - 132								BMW - 801						
	HE-115	Hs-126	Fw-200	Ju-52	Do-24	Ar-95	Ju-90	Total	Fw-190	Ju-88	Do-217	Fw-200	Ha-141	Total	Total
1939															
June	30	50	20	90	15	5	20	230	-	-	-	-	-	-	230	460
July	30	55	20	90	15	5	20	235	-	-	-	-	-	-	235	470
Aug.	30	55	20	90	15	5	20	235	-	-	-	-	-	-	235	470
Sept.	30	55	20	90	15	5	20	235	-	-	-	-	-	-	235	470
Oct.	40	55	20	90	15	5	20	245	-	-	-	-	-	-	245	490
Nov.	40	55	20	90	15	5	20	245	-	-	-	-	-	-	245	490
Dec.	40	55	20	105	15	5	20	260	-	-	-	-	-	-	260	520
Tot '39	240	380	140	645	105	35	140	1,685	-	-	-	-	-	-	1,685	3,370
1940															
Jan.	40	55	20	105	30	5	20	275	-	-	-	-	-	-	275	550
Feb.	40	55	20	105	30	5	20	275	-	-	-	-	-	-	275	550
Mar.	40	55	20	120	30	10	20	295	-	-	-	-	-	-	295	590
Apr.	40	55	20	120	30	10	20	295	-	-	-	-	-	-	295	590
May	40	55	20	120	30	10	20	295	-	-	-	-	-	-	295	590
June	40	55	20	120	30	10	20	295	-	-	-	-	-	-	295	590
July	40	55	20	120	30	10	20	295	-	-	-	-	-	-	295	590
Aug.	40	55	20	135	30	10	20	310	-	-	-	-	-	-	310	620
Sept.	40	55	20	135	30	10	20	310	-	-	-	-	-	-	310	620
Oct.	40	55	10	150	30	10	20	315	5	-	-	10	-	15	330	660
Nov.	40	55	10	150	30	10	20	315	5	-	-	10	-	15	330	660
Dec.	40	55	10	150	30	10	20	315	10	-	20	10	-	40	355	710
Tot. '40	480	660	210	1,530	360	110	240	3,590	20	-	20	30	-	70	3,660	7,320
1941															
Jan.	40	55	10	150	30	10	20	315	10	-	40	10	-	60	375	750
Feb.	40	55	10	150	30	10	20	315	15	-	60	10	-	85	400	800
Mar.	40	55	10	150	30	10	20	315	20	-	70	10	-	100	415	830
Apr.	40	55	10	135	30	10	20	300	20	-	80	10	-	110	410	820
May	40	55	10	135	30	10	20	300	20	-	110	10	-	140	440	880
June	30	55	10	135	30	10	20	290	30	-	130	10	-	170	460	920
July	30	55	10	135	30	10	20	290	35	-	130	10	-	175	465	930
Aug.	30	55	10	135	30	10	20	290	45	-	140	10	-	195	485	970
Sept.	30	55	10	135	30	10	20	290	50	-	140	10	-	200	490	980
Oct.	30	45	10	135	30	10	20	280	55	70	140	10	10	285	565	1,130
Nov.	30	45	10	135	30	10	20	280	70	70	140	10	10	300	580	1,160
Dec.	30	40	10	135	30	10	20	275	80	70	140	10	10	310	585	1,170
Tot. '41	410	625	120	1,665	360	120	240	3,540	450	210	1,320	120	30	2,130	5,670	11,340
1942															
Jan.	30	40	10	135	30	10	20	275	80	80	140	10	10	300	575	1,150
Feb.	30	40	10	135	30	10	20	275	85	80	140	10	10	305	580	1,160
Mar.	30	40	10	135	30	10	20	275	90	80	140	10	10	310	585	1,170
Apr.	30	40	10	135	30	10	20	275	95	80	150	10	10	325	600	1,200
May	30	40	10	135	30	5	20	270	100	90	150	10	10	330	600	1,200
June	30	40	10	135	30	5	20	270	110	90	150	10	10	340	610	1,220
July	30	40	10	135	30	5	20	270	110	100	150	10	10	380	650	1,300
Aug.	30	40	10	135	30	5	20	270	120	100	150	10	10	390	660	1,320
Tot. '42	240	320	80	1,080	240	80	160	2,180	790	560	1,170	80	80	2,080	4,860	7,100

TABLE IX

Estimated Output of Junkers Motors

Date	Production per Engine Frame									Est. Total Production (twice est. prod./engine frame)
	Ju-205			Ju-207	Ju-211					
	Do-18	Hs-138	Total	Ju-86-P	Ju-87	Ju-88	Ju-89	He-111-K Va.	Total	
1939										
June	10	30	40	-	80	200	20	-	300	340	680
July	10	30	40	-	90	240	20	-	350	350	780
Aug.	20	30	50	-	100	250	20	-	370	420	840
Sept.	20	30	50	-	110	290	20	-	420	470	940
Oct.	20	30	50	-	120	290	20	-	430	480	960
Nov.	20	30	50	-	125	350	20	-	495	545	1,090
Dec.	20	30	50	-	130	370	20	-	520	570	1,140
Tot.'39	120	210	330	-	755	1,990	140	-	2,885	3,215	6,430
1940										
Jan.	20	30	50	-	135	430	20	-	585	635	1,270
Feb.	30	30	60	-	140	460	20	-	620	680	1,360
Mar.	30	30	60	-	145	480	20	-	645	705	1,410
Apr.	30	30	60	-	145	510	20	150	825	885	1,770
May	30	45	75	-	145	520	20	150	835	910	1,820
June	30	45	75	-	145	530	20	160	855	930	1,860
July	30	45	75	-	145	550	20	160	875	950	1,900
Aug.	30	45	75	-	145	560	20	160	885	980	1,920
Sept.	30	45	75	-	140	570	20	160	890	965	1,930
Oct.	30	45	75	-	140	570	20	170	900	975	1,950
Nov.	30	60	90	-	135	580	20	170	905	995	1,990
Dec.	30	60	90	-	130	580	20	170	900	990	1,990
Tot.'40	350	510	860	-	1,690	6,340	240	1,450	9,720	10,580	21,160
1941										
Jan.	30	60	90	-	125	590	20	180	915	1,005	2,010
Feb.	30	60	90	-	120	590	20	190	920	1,010	2,020
Mar.	30	60	90	-	115	600	20	190	925	1,015	2,030
Apr.	30	60	90	-	115	620	20	190	945	1,035	2,070
May	30	60	90	-	100	630	20	190	940	1,030	2,060
June	30	60	90	-	90	640	20	190	940	1.030	2.060
July	30	60	90	-	85	660	20	190	955	1,045	2,090
Aug.	30	60	90	-	85	670	20	190	965	1,055	2,110
Sept.	30	60	90	-	85	670	20	190	965	1,055	2,110
Oct.	30	60	90	10	85	610	20	190	915	1,005	2.010
Nov.	30	60	90	10	85	610	20	190	915	1,005	2,010
Dec.	30	60	90	10	85	610	20	190	915	1,005	2,010
Tot.'41	360	720	1,080	30	1,175	7,500	240	2,270	11,215	12,295	24,590
1942										
Jan.	30	60	90	10	90	600	20	180	900	990	1,980
Feb.	30	60	90	10	90	610	20	180	910	1,000	2,000
Mar.	30	60	90	10	90	610	20	190	920	1,010	2,020
Apr.	20	60	80	10	90	620	20	190	930	1,010	2,020
May	20	60	80	10	90	620	20	190	930	1,010	2,020
June	20	60	80	10	90	620	20	190	930	1,010	2,020
July	20	60	80	10	90	610	20	190	920	1,000	2,000
Aug.	20	60	80	10	90	620	20	190	930	1,010	2,020
Tot.'42 (8800)	190	480	670	80	720	4,910	160	1,500	7,370	8,040	16,080

TABLE X

Estimated Output of Bramo, Arado, and Gnome-Rhone
Aircraft Motors In Tactical Aircraft

Date	Production per Engine Frame								Est. Total production (twice est. prod./engine frame)
	Bramo Pafner		Total	Ar-410		Total	Rhone-14m	Total	
	Do-17Z	Ar-196		F.W.-189	Hs-129		Hs 129		
1939									
June	45	15	60	20	-	20	-	80	160
July	45	15	60	20	-	20	-	80	160
Aug.	45	15	60	20	-	20	-	80	160
Sept.	45	15	60	20	-	20	-	80	160
Oct.	50	15	65	20	-	20	-	85	170
Nov.	50	15	65	20	-	20	-	85	180
Dec.	50	20	70	30	-	30	-	100	200
Tot.'39	330	110	440	150	-	150	-	590	1,180
1940									
Jan.	50	20	70	30	-	30	-	100	200
Feb.	50	20	70	30	-	30	-	100	200
Mar.	50	20	70	30	-	30	-	100	200
Apr.	50	20	70	30	-	30	-	100	200
May	50	20	70	30	-	30	-	100	200
June	50	20	70	30	-	30	-	100	200
July	50	20	70	30	-	30	-	100	200
Aug.	55	20	75	30	-	30	-	105	210
Sept.	55	20	75	40	-	40	-	115	230
Oct.	55	20	75	40	-	40	-	115	230
Nov.	55	20	75	40	-	40	-	115	230
Dec.	45	20	65	40	-	40	-	105	210
Tot.'40	615	240	855	400	-	400	-	1,255	2,510
1941									
Jan.	35	20	55	40	-	40	-	95	190
Feb.	25	20	45	40	-	40	-	95	190
Mar.	20	20	40	40	-	40	-	80	160
Apr.	10	20	30	40	10	50	-	80	160
May	10	20	30	40	20	60	-	90	180
June	5	20	25	40	30	70	-	95	190
July	5	20	25	40	30	70	-	95	190
Aug.	-	20	20	40	30	70	-	90	180
Sept.	-	15	15	40	40	80	-	95	190
Oct.	-	15	15	30	40	70	-	85	170
Nov.	-	15	15	30	40	70	-	85	170
Dec.	-	15	15	30	40	70	-	85	170
Tot.'41	110	220	330	450	280	730	-	1,070	2,140
1942									
Jan.	-	15	15	30	-	30	40	85	170
Feb.	-	15	15	30	-	30	40	85	170
Mar.	-	15	15	30	-	30	40	85	170
Apr.	-	15	15	30	-	30	40	85	170
May	-	15	15	30	-	30	40	85	170
June	-	15	15	30	-	30	40	85	170
July	-	15	15	30	-	30	40	85	170
Aug.	-	15	15	30	-	30	40	85	170
Tot.'42	-	120	120	240	-	240	320	680	1,360